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# Shelter Scape 7: Combining Regenerative and Earth Sheltered Practices for a New Housing Community in Massachusetts

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# Shelter Scape7

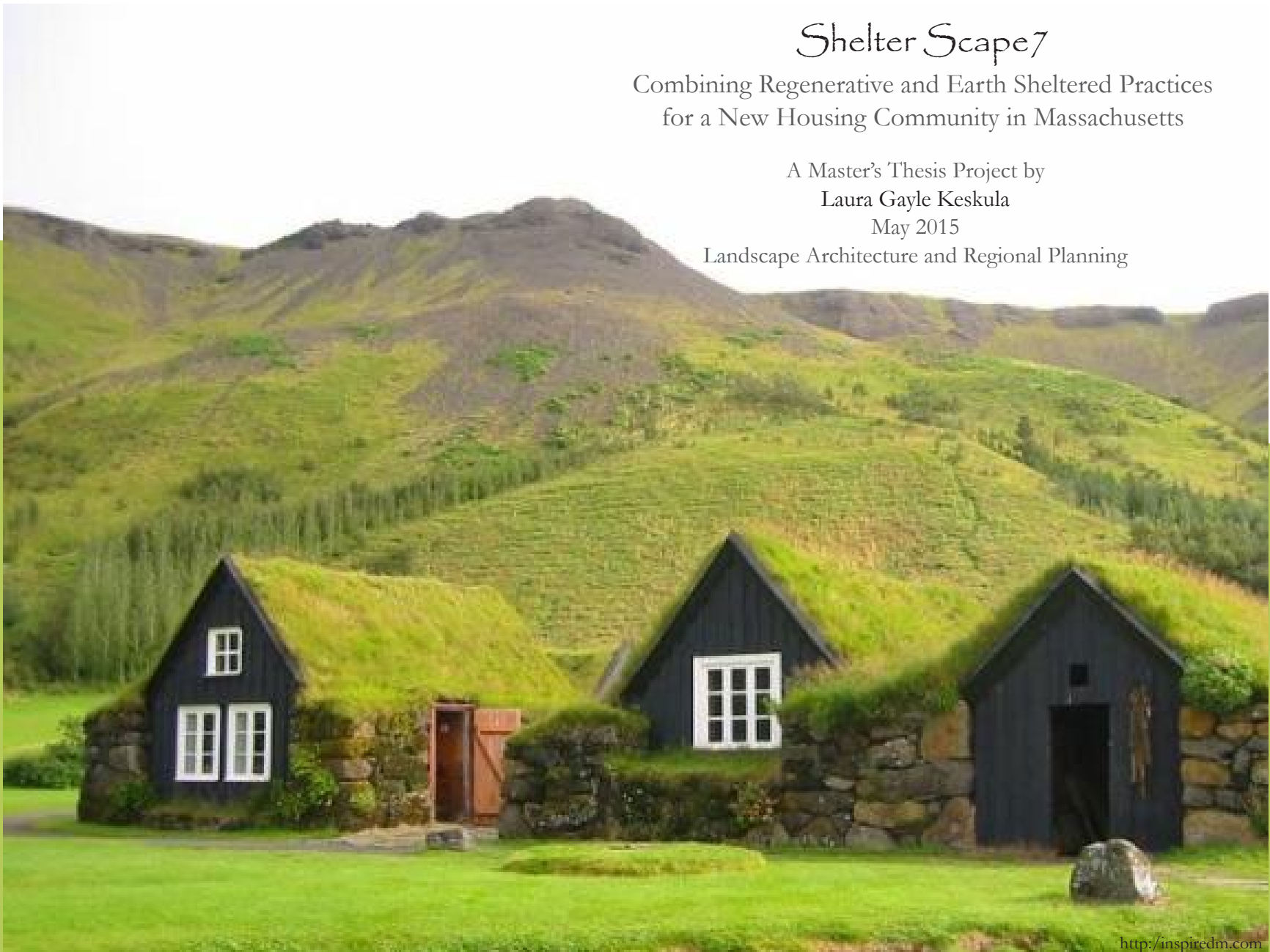
Combining Regenerative and Earth Sheltered Practices  
for a New Housing Community in Massachusetts

A Master's Thesis Project by

Laura Gayle Keskula

May 2015

Landscape Architecture and Regional Planning



<http://inspiredm.com>





# Shelter Scape7

Combining Regenerative and Earth Sheltered Practices  
for a New Housing Community in Massachusetts



Master's Thesis Project  
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Master's in Landscape Architecture

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May 2015



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Thank you, and I am eternally grateful to you all.

*for James*

*where do we go from here*

---





## Abstract

Global Climate is projected to change significantly over the next decade. Given the potential impact of these changes, human relationships with the landscape will change. We as a people will have to re-evaluate our behaviors, activities, and aesthetics; our communities might have to re-assess and re-classify our current land use designations, as is the case potentially for Wachusett Mountain Ski Area in Princeton, Massachusetts. Under the projected climatic changes, the future snow making and sustaining ability of this mountain is of question and at potential risk; these questions therefore beg the discussion of what to do instead with similar sites, and on a broad scale, of how to best respond to the changes. Landscape design and architecture will be at the forefront of responding to this new environment, and a subsequent holistic integration of these two fields presents an effective way forward. Landscape designs will have to do more than appeal visually, and they will be judged by their capacity to support and sustain a strong level of species biodiversity and habitat, as well as food production. Supporting these needs are regenerative landscapes which work with nature rather than in contradiction to, and as a result, seek to help ensure our lasting survival. Earth sheltered housing communities offer the most holistic integration of human shelter needs and landscape ecology. The union of a regenerative community with earth sheltered housing represents the best effort of sustainability that we humans have so far built; and at this point it has not been notably achieved. The proposed designs of Shelter Scape7 embody that union. On sixty acres of Wachusett Mountain, Shelter Scape7 captures resources, collects the community, cultivates food security, and contributes sustainable habitat for all species. Shelter Scape7 shelters us, and it shelters nature from us, for our generation and also for seven generations in the future.

# CONTENTS

1	SCOPE	
	Introduction	2
	Goal and Objectives	5
	Deliverables	6
2	LITERATURE REVIEW	
	Regenerative Design	8
	Permaculture	11
	Greywater Reuse and Infiltration	15
	Humanure and Black Water	19
	Earth Sheltered Houses	23
	Terminology	27
	Malcolm Wells	27
	Construction and Benefits	29
	Passive Solar Energy	31
	Earth Sheltered Communities	35
	Other Earth Sheltered Typologies	37
	Bunkers	37
	Fallout Shelters	39
	Cave Dwellings	43
	Pit Houses	44
	Icelandic Turf Houses	46
	Earthships	48
3	CASE STUDIES	
	The John T. Lyle Center for Regenerative Studies; Pomona, California	52
	“The [Ideal] Bunker”; Southborough, Massachusetts	58
	Sheltered South Eastern; Belchertown, Massachusetts	64
	Walnut Canyon National Monument; Flagstaff, Arizona	70



4	METHODOLOGY	
	Regenerative Landscape Strategies	76
	True Regenerative Implementations	77
	Earth Sheltered Architecture Strategies	79
	Regenerative Community Strategies	81
5	SITE OVERVIEW AND DESIGN IMPLEMENTATION	
	Locality Justification	84
	Wachusett Mountain	85
	Princeton, Massachusetts	87
	Mountain Analysis and Assessment	93
	GIS Maps	94
	Site Challenges and Limitations	103
	Approach	105
	Design Site Photo Tour	111
	Concept and Design	115
	Master Plans	120
	Community East Floor Plan and Housing Elevations	121
	Landscape Section Elevations	122
	Construction Documents	130
	Crop West Section Sketches	136
6	CONCLUSION	
	Summary	140
	Lessons Learned	141
	Annotated Bibliography	145
	Appendix	151
	Wachusett Mountain Hiking Trail Map	151
	Wachusett Mountain Lodge and Base Area Map	152





<http://wachusett.com>

## CHAPTER 1: SCOPE

### Introduction

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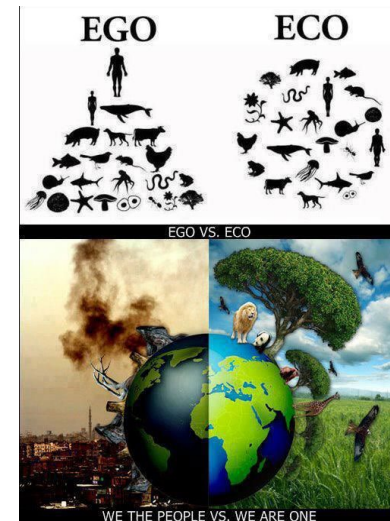
Global climate is projected to change significantly over the next decade (IPCC, Working Group 1). Areas deemed hospitable in current times may not prove suitable in coming years due to excessive heat, flooding risk or, other climatic changes of the landscape. Land use and recreational functions operating off our land currently may also prove inoperable or unsustainable in the future. Given the potential impact of these climatic changes, human relationships with the landscape, and suitable regional housing sites could change. Residential Architecture will have to adapt to fit these new relationships, and a focus on building regenerative and earth sheltered communities may result. Regenerative communities work with nature rather than in contradiction to, and they seek to be wholly sustainable, energy independent, and food secure. Earth sheltered homes are designed to work with nature and be harmonious and minimally disruptive to the natural landscape. In an ideal situation, earth sheltered homes are built into existing hillsides on a southern axis and sheltered with earth on three or four sides when including the roof. The southern facing orientation, typically with a windowed façade, offers maximum passive solar heat gain through the glass. The roughly constant temperature of the earth paired with the passive solar features both allow for a lessening of home heating and cooling costs. A subsequent union of the concept of regenerative communities and earth sheltered housing may prove, therefore, to represent the best effort of sustainable design that humans have so far built. At this point, this union has not been notably achieved.

In addition to global climate populations are expected to increase as well. Worldwide, according to United Nations Population Division data of 2014, total populace is projected to number 9.6 billion by 2050 (Census 2015). This number is expected to grow, and in the United States population is expected to reach 400 million by 2051 (Ibid). In Massachusetts alone the population is projected to increase 4.4% by year 2030 (Renski 2013, 14).

Due in part to this projection, and the ever increasing pressure for development on forested or prior and existing farmland, there poses an additional critical need to provide homes on sites previously deemed unsuitable due to topography, and that of which are also harmonious with the land upon which they develop. Development of prior wooded or agricultural lands not only disturbs and often destroys natural ecosystems, but it also degrades cultural land significance, diminishes native and domestic food supplies, and also represents the old way of thinking of man as top of the food chain and nature as the element to *take from* rather than *work in an ecological partnership with*.



<http://images.nationalgeographic.com>



<http://thenatureofbusiness.org>

In short, to balance climate and population projections with ecological sustainability, it is the goal of this project to determine whether the possibility of combining regenerative and earth sheltered housing designs into a complete regenerative community with earth sheltered housing is feasible on Wachusett Mountain in central Massachusetts.



<http://www.small-house-building.com>

## Goal

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The primary goal of this project is to integrate regenerative community and earth sheltered housing typologies into a new regenerative community with earth sheltered housing designs, and as a way to respond to climate change potentials and resulting land use modifications, subsequently determine if this ensuing design is feasible on approximately sixty acres of the currently operating Wachusett Ski Mountain in Princeton, Massachusetts.

This regenerative landscape design could inspire other similar community designs, or ideally, among students, architects, designers, and contractors stimulate an increase in more innovative design approaches to regenerative landscapes and sustainable earth integrated communities both on ideal and less than ideal sites.

## Objectives

---

- Perform on location and GIS site analysis that identifies the most viable ecological location for development.
- Based on national and local case studies and research identify a tool box that explores typical typologies of regenerative communities and earth sheltered housing, and implement these typologies into an integrated community design.
- Develop a master plan that depicts regenerative landscape features integrated with earth sheltered housing construction. This plan will show long term (after Mountain lease termination in 2055) implementation of additional housing added to help increase town populations and revenue, increase local food options, provide a use for a former ski mountain that has potentially ceased to operate and notably exist as a model for sustainable and regenerative community housing.

## Deliverables

---

- Provide a master plan of sixty acres of the mountain, encompassing the sloping northeast facing trails, visitor center, pond and partial main parking lot. This plan will include new uses for the visitor center, other existing buildings, pond, landscape and existing chair lifts, and will show the integration of twenty variable houses into the surrounding landscape.
- In plan, section and floor plan, design and depict two typical housing styles for this site which are based on local case study analysis and precedent research.
- Additional sections and diagrams will also depict common sustainable and organic food growing practices, and will show community character and an exploration of various landscape relationships.
- A set of buildable construction documents including materials, grading, planting, section elevations and details depicting designed houses, main areas and landscape features will also be provided.





Figure 1



## CHAPTER 2: LITERATURE REVIEW

### Regenerative Design

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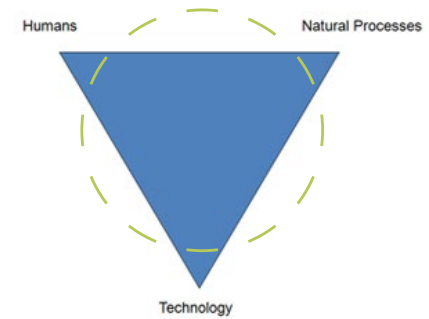


Figure 2  
<http://www.cpp.edu>

Regenerative design as coined perhaps by Robert Rodale and popularized by John Lyle, is as written by Lyle in 1994 as “replacing the present linear system of throughput flows with cyclical flows at sources, consumption centers, and sinks...(It) has to do with rebirth of life itself, thus with hope for the future” (Lyle 1999, v).

In a simplified sense, regenerative landscapes are really community support systems that restore, renew, revitalize, and regenerate through integration with natural processes, technology, human behavior and the action of community involvement (Figure 2; Lyle 1994, 11). Designs based on this criteria and in line with Lyle’s vision are those that provide infrastructure needed to manage essential functions including those related to water, food, shelter, energy and waste (Ibid). The landscapes “grow food, generate energy, regulate [their] own thermal environment and recycle wastes” as well as respond heavily to the natural relationship with the land which is evident in their form and structure (Ibid).

Lyle explains further that proper ways for achieving regeneration can vary based on local site conditions depending on solar orientation,



prevailing winds, hydrology, topography, soil suitability, and climate (Lyle 1994, 24). Today there is much talk about regenerative landscapes, and most often they are thought of and implemented as ways to aesthetically manage stormwater or habitat and water quality remediation. Turenscape's popular Minghu Wetland Park (Figure 3) is a good example as it was designed out of a desire to improve the water quality and habitat of the polluted Shuicheng River, and after successfully doing so is now also regarded as a regenerative landscape (Wang 2015).

Another aspect of regeneration which is currently popular, as this image from a new central Massachusetts installation shows is the installation of massive arrays of Photovoltaic Panels. While these panels will generate power from the absorption of the striking sun, some critics have called these installations "Solar Death Panels" because their setup often requires the destruction of normally wooded or grassland areas, and also perhaps represents the old way of thinking about the landscape- as ours for the taking rather than a partnership with (Figure 4).

However, in line with Lyle's regeneration, and in its most fundamental and true sense, regeneration is a holistic integration of many natural processes and functions. This resulting integration therefore often exhibits a "messier" and not as aesthetically or traditionally pleasing to the eye design. For this integration to be implemented on the broad scale there perhaps needs to be a perception change as identified in 1995 by Joan Nassauer's- "Messy Ecosystems, Orderly Frames" concept. She explains if traditional aesthetic qualities of clean lines, similar spacing and tight lawns are integrated with the "messier" unkempt elements of functioning nature then perhaps people will accept the messier because it is framed as orderly (Figure 1). In a design sense, a regenerative landscape would in effect, look more like the permaculture model which largely views nature as the model and is considerably messier than the traditional design aesthetic as is explained in following pages.

Therefore, true regeneration, when thought of as a holistic integration of natural processes and functions and which exhibits the "messier" permaculture design aesthetic, is perhaps the most sustainable form of design. These landscapes too go beyond sustainability in that, on their own, based on natural processes and renewable innovation, they generate new and provide for future changing uses, rather than just providing for today at no expense of the future renewal potentials. The major difference is the *working* aspect- the *generation*, not just conservation, preservation, or the implication that the future will provide on its own.



Figure 3  
<http://assets.inhabitat.com>



Figure 4

## Permaculture

---

Permaculture, or “Permanent Agriculture and Culture”, as was developed as a concept in 1974 by Australian native Bill Mollison and his student David Holmgren, “Is a word...coined for an integrated evolving system of perennial or self perpetuating plant and animal species useful to man” (Holmgren 1990, 1). Specifically, permaculture, sometimes called cultivated ecology or “applied disturbance ecology” as it responds to humans disturbance on the land, is a system of design and agriculture that creates sustainable human developments while supporting a logical and ecological partnership with nature (Falk 2013, 29; 7).

It is primarily a way of thinking, behaving, and organizing, and is fundamentally based on three core principles: Care of the Earth, Care of the People, and Dispersal of Surplus Time, Money and Materials (Mollison 1991, 3). ‘Caring of the Earth’ results in organic farming practices supporting ‘Cooperation not Competition’ from plant and animal species, and sustainable land processes often regarding nature and the forest as the perfect growing model (Figure 5, 6). Caring of the People’ also yields organic food production, crop and water security and an overall simple approach to living. ‘Dispersal of Surplus Time results in the organizational elements that are key to the concept. For ease of access and maintenance, tools of the space are grouped with functions and uses of the space, and a holistic planning of all integral elements is made before gardens and spaces are sited. ‘Zones’ of use are outlined as these key organizational features and elements such as those requiring the most maintenance and daily attention; ie. animal barns and kitchen gardens; are placed in zone one, and elements requiring less time and maintenance are placed in zone 2, and so on (Figure 7).





Figure 5  
<http://www.urbanpermacultureguild.org>



Integral again to the sustainability is of course the educational and community involvement aspect Lyle previously explained, and this part of the triangle is evident in many permaculture and regeneration based foundations; one such being the South African foundation Afristar, which through published posters, booklets, and film documentaries tries to educate communities and schools that permaculture and regeneration is fun and easy (Afristar, 2013).

## COMPANION PLANTING

IN NATURAL ECOSYSTEMS, PLANTS PERFORM FUNCTIONS THAT CAN EITHER HELP OR PREVENT OTHER PLANTS TO GROW. THE SAME IS TRUE IN OUR GARDENS. CERTAIN PLANTS GIVE NUTRIENTS BACK TO THE SOIL, WHILE OTHERS NEED TO TAKE UP NUTRIENTS. PLANTING HERBS AND FLOWERS CAN ATtract POLLINATORS OR WORMS. BELOW IS A CHART TO HELP YOU UNDERSTAND WHICH PLANTS GROW WELL TOGETHER AND WHICH TO PLANT FAR APART.

PLANT	GOOD COMPANIONS	BAD COMPANIONS
BEANS	MAIZE, SUNFLOWERS, LAVENDER, CABBAGE, CUCUMBER, STRAWBERRIES, BRINJAL	ONION, GARLIC, FENNEL
BEEFROOT	BEANS, ONIONS, GARLIC, LETTUCE, CABBAGE	
BRINJAL	CALENDULA, MARIGOLDS, MINT, PEAS	
BROCCOLI, CABBAGE, CAULIFLOWER, KALE	AROMATIC PLANTS, DILL, SAGE, ROSEMARY, POTATOES, BEETROOT, CELERY, GARLIC, ONIONS, GERANIUM	TOMATOES, POLE & RUNNER BEANS, PEPPERS
CARROTS	LETTUCE, CHIVES, LEEKS, ROSEMARY, SAGE, PEAS, WOODWOOD	STRAWBERRIES, FENNEL, CABBAGE
LETTUCE	CARROTS, RADISH, STRAWBERRIES, CUCUMBER, BEANS	CELERY, PARSLEY
MAIZE	SUNFLOWERS, AMARANTH, BEANS, PEAS, & OTHER LEGUMES, PUMPKIN, SQUASH, CUCUMBER, MELON, & OTHER CUCURBITS, PARSLEY	CABBAGE, TOMATO, CELERY
ONION/ GARLIC	CARROTS, BEETROOT, STRAWBERRIES, TOMATOES, LETTUCE, CABBAGE	PEAS, BEANS, PARSLEY, LEEKS
PEAS	LAVENDER, CARROT, TURNIP, RADISH, CUCUMBER, MAIZE, BEANS, GROWS WELL WITH MOST VEGETABLES & HERBS	ONION, GARLIC
PEPPERS	TOMATOES, GERANIUM, BASIL, CARROT, ONION	BEANS, KALE, CABBAGE FAMILY
POTATOES	CORIANDEr, MARIGOLD, BEANS, MAIZE, CABBAGE FAMILY, BRINJAL	PUMPKIN, CUCUMBER, SQUASH, MELONS, SUNFLOWERS, TOMATOES
SPINACH	STRAWBERRIES, BROAD BEANS, PEAS	POTATOES, FENNEL, CABBAGE FAMILY
TOMATOES	BASIL, OREGANO, PARSLEY, CHIVES, NASTURTIUM, ONIONS, CARROTS, CELERY, CALENDULA, GERANIUM, SORREL	
CALENDULA	TOMATOES - REPELS TOMATO WORM!	GENERAL PEST DETERRENT, PLANT THROUGHOUT GARDEN
COMFREY	FAST-GROWING NUTRIENT ACCUMULATOR. PLANT ALONG EDGES & USE LEAVES FOR MULCH	COMPOST ACTIVATOR. USE LEAVES TO MAKE COMFREY TEA FERTILIZER!
CHILE PEPPER	CABBAGE, MAIZE	REPELS CABBAGE MOTH. PLANT ON ROBBERS TO KEEP FLYING PESTS AWAY!
MARIGOLD	PLANT FREELY THROUGHOUT THE GARDEN - REPELS SOIL NEMATODES, APHIDS, BEAN BEETLES & MANY MORE.	USE MARIGOLD LEAVES TO MAKE AN ORGANIC GENERAL INSECTICIDE SPRAY!
NASTURTIUM	TOMATOES - IMPROVES FLAVOR!	REPELS WHITE FLIES & SPIDER MITES
THYME	CABBAGE	DETERS CABBAGE WORM
ROSEMARY	CARROTS, CABBAGE, SAGE, BEANS	DETERS CABBAGE MOTH, BEAN BEETLES & CARROT FLY!
WORMWOOD/ ARTEMESIA	AROUND GARDEN EDGES	KEEPS ANIMALS OUT! ALSO REPELS WHITE FLY
YARROW	PLANT FREELY THROUGHOUT THE GARDEN. REPELS SOIL NEMATODES, APHIDS, BEAN BEETLES, & MANY MORE.	

A DIVERSE GARDEN IS AN ABUNDANT GARDEN. HAPPY PLANTING!

Figure 6

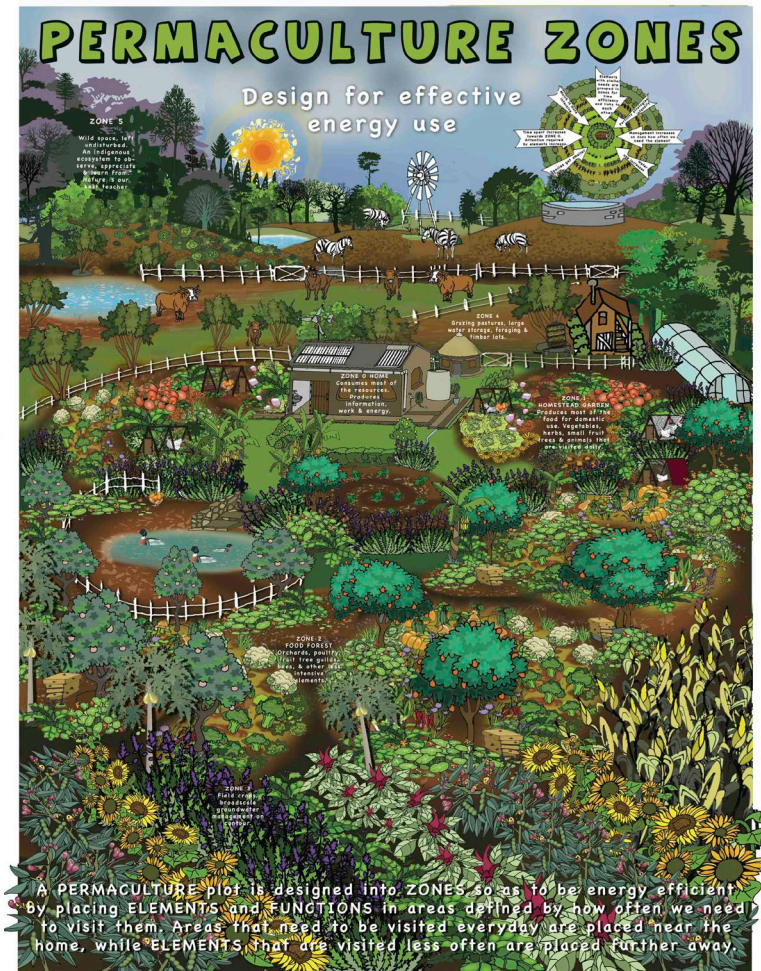


Figure 7

<http://afristarfoundation.org>



Another part of permaculture is the relationship humans and agriculture have with water (Figure 8). In order to effectively irrigate crops and support the partnership with the natural ecosystem, water collection through above and below ground cisterns and rain barrels, and greywater recycling, infiltration and reuse are practiced (Figure 9). Generally roofs used to intercept and disperse rain water are comprised of metal, slate, or tile as to limit water pollutant contamination, and rain barrels and cisterns are opaque to limit solar induced bacterial growth. A variety of greywater infiltration methods are often employed as further explained in the following pages.

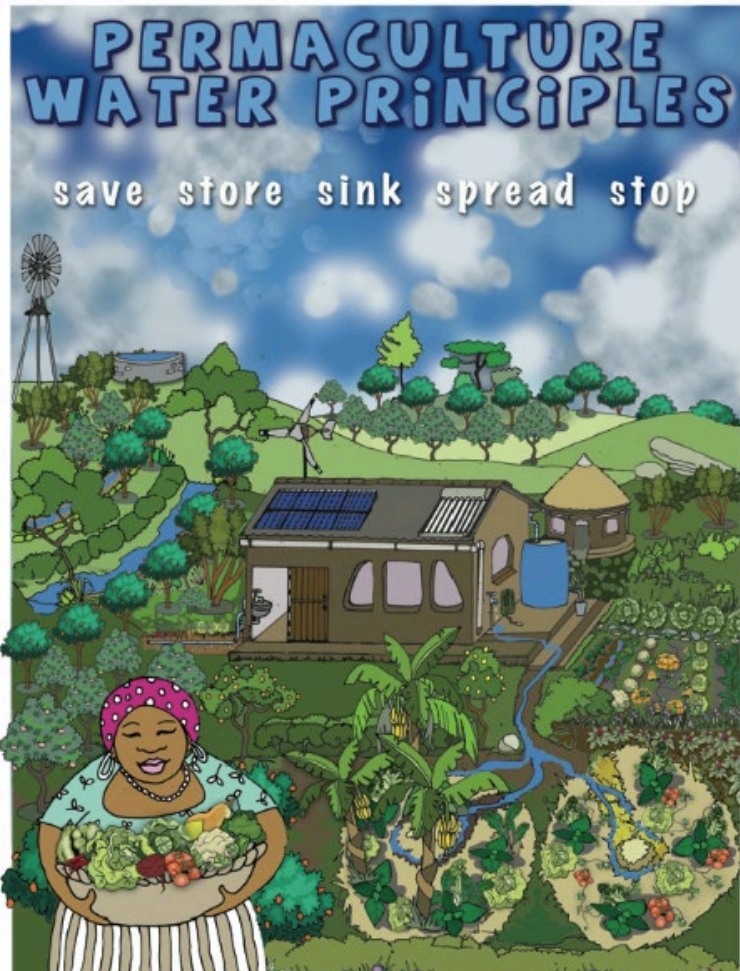


Figure 8



Figure 9

<http://afristarfoundation.org>

## Greywater Reuse and Infiltration

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Greywater is the “wastewater” produced from dish, sink, shower, and laundry applications. This water is largely suitable for crop and landscape irrigations and is most certainly not “waste” and should not be treated as such (Ludwig 2014, 2). Toilet water is referred to as ‘blackwater’, and this water requires a more sophisticated form of disposal and material breakdown and therefore is not included in greywater applications.

Greywater comprises approximately 50-80% of residential “wastewater”, or about on average, the total of 90 gallons per day (Ludwig 2014, 4). Conventionally this water is disposed of in septic systems which have leach field outflows or sewer lines that continue to water treatment facilities which upon mixing with often hazardous chemicals from industrial facilities and toilets wastes, treats and disposes of the product into rivers and other water body outlets, or often releases the waste untreated, thus increasing combined sewer overflows (Ibid).

Benefits to the reuse of greywater are considerable to any area across the globe, however no area is perhaps more suitable and offering the most ecological and economic gain than those areas prone to drought and overall lack of water. A reuse and infiltration of greywater in these areas could revitalize the ecosystem, increase habitat and food security, and contribute to a regenerative landscape. Due to the increased water in the soil, benefits to greywater reuse include less crop losses and erosion, higher crop yields, a reclamation of soil fertility, or the newly coined term “fertigation” which is irrigation water enhanced with greywater nutrients and minerals. Fertigation promotes less stress on the plant, thus reducing fertilizer needs and pesticides applications; and an increase in drinking water supplies as this infiltration recharges the ground water table (Ludwig 2014, 3). On site greywater reuse also reduces the strain on septic and sewage treatment facilities, and reduces the need for toxic chemicals in these facilities as soil ultimately purifies better than synthetics and chemicals. Additionally, greywater reuse is broadly feasible and possible on sites deemed unsuitable for septic systems due to a high water table, or slowly, poorly draining soils (Ibid).





<http://www.npr.org>



On site greywater infiltration is, however, highly context dependent, and areas deemed unsuitable should be avoided. Proper infiltration occurs in areas of multiple zones, both with close to the surface infiltration capabilities and others allowing long infiltration periods to reduce bacteria and pathogens present in the water. As general rules slopes of designated infiltration zones must be greater than 2% gradient, soils should not be excessively well drained or supporting of restrictive layers, ample infiltration space should be provided and other buildings should be at an appropriate distance away, drain pipes should be accessible, and the climate should support flowing water at least part of the year (Ludwig 2014, 3). Plants used for zonal infiltration capabilities consist of wetland, marginal ornamental, and fruit species; root crops and acid loving plants should be avoided (Ludwig 2014, 46). Lawns are also not recommended for greywater infiltration due to their limiting purification potential, and all household products including soaps and cleansers should be of organic, or biodegradable formulas and should not contain salts (including those from water softeners and powdered detergents), sodiums, boron, or bleach (Ludwig 2014, 102).

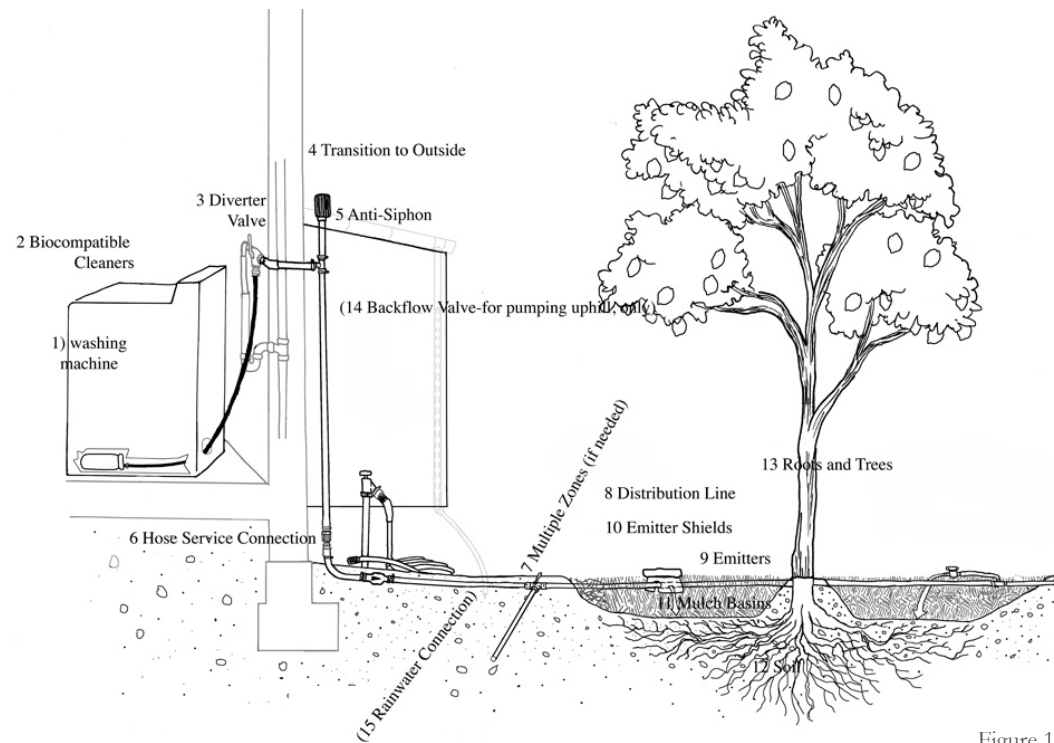


Figure 10  
<http://www.oasisdesign.net>

Many systems of greywater infiltration are practiced with variable levels of success and efficiency. Those systems include Landscape Direct, Laundry to Landscape (Figure 10), Movable Drains, Branched Drain Greywater Furrows/Swales and Mulch Basins (Figure 11), and Hydrophytic Zone Constructed Wetlands. All systems require the previously mentioned criteria, but each differ with the level of system installation and maintenance, water filtering capabilities, overall landscape aesthetic and end result. For purposes of this project, Branched Drain Greywater Furrows/ Swales and Mulch Basins are employed as is detailed below in Figure 11.

#### GREYWATER CONTAINED AND COVERED IN A BRANCHED DRAIN-FED MULCH BASIN (ELEVATION VIEW)

*Enclosed chamber option shown at left, clear discharge option shown at right  
(you can skip the rest of the details for now, we'll refer back to this figure later).*

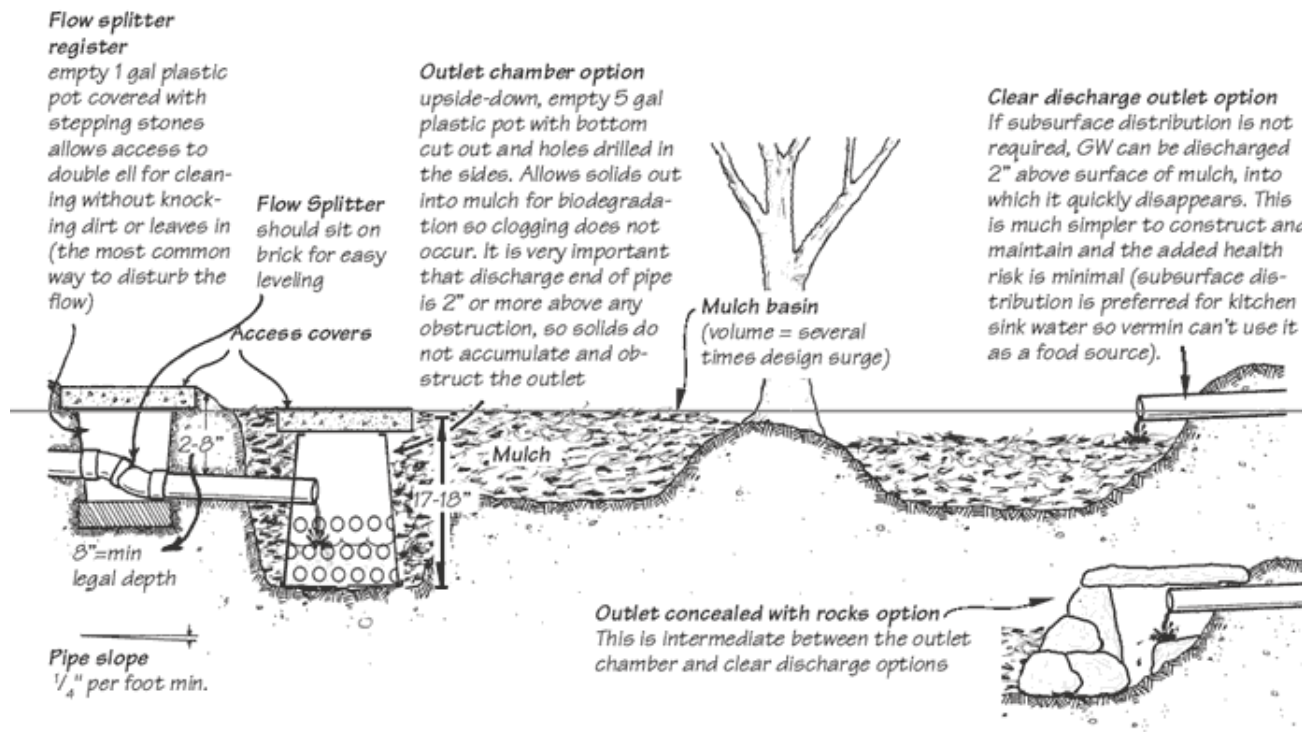


Figure 11  
<http://www.oasisdesign.net>

## Humanure and Black Water (waste)

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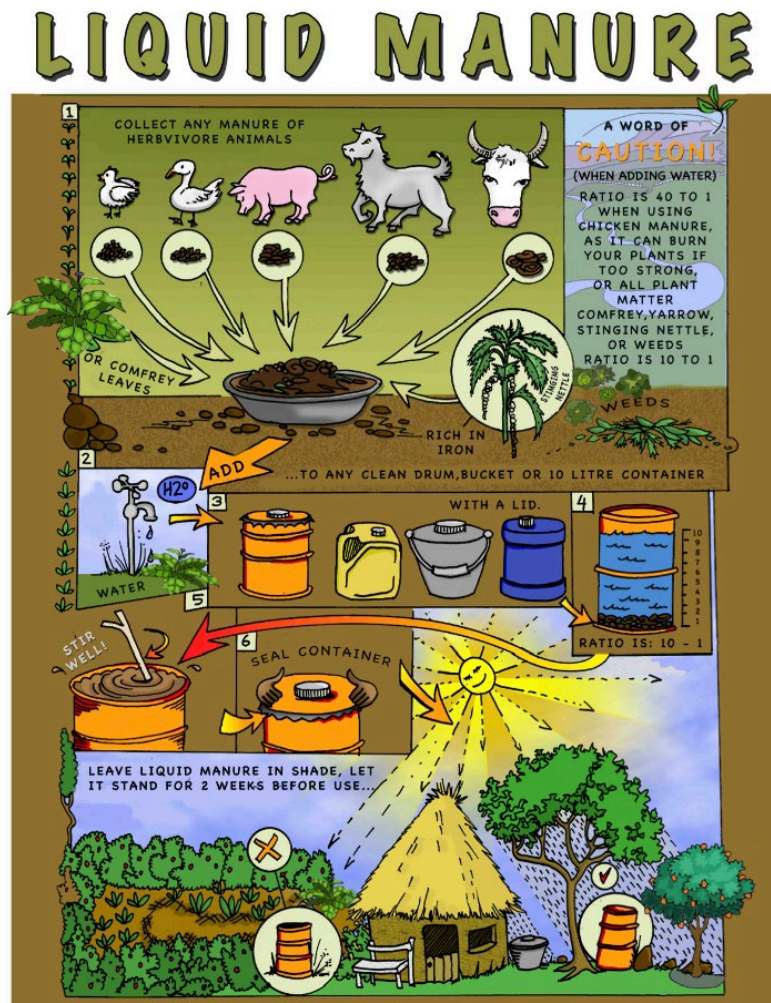
A well known and practiced element of organic farming/gardening and permaculture is the spreading of animal manures for fertilization of crops and landscape plants. A lesser known element is perhaps the composting and subsequent spreading of human manures for the same fertilization.

Conventional toilets use fresh, potable, drinking water to flush away waste. This practice typically, with the average person flushing six times per day, wastes about eight thousand gallons of water per year (Jenkins 2005, 115; 207). Instead of wasting drinking water, using a popular brand of commercially available composting toilet, this same person could produce eighty eight pounds of manure annually (Jenkins 2005, 115) (Figure 12-13). Worldwide this number on average reaches 1.75 million tons per day or 600 million tons per year of manure that is wasted by flushing it down the drain (Jenkins 2014, 2).

Historically, across the globe, humanure, or the composted waste produced by humans, was (and in some places still is) a precious resource that was highly valued for agricultural fertilization purposes and even medicinal and cosmetic properties (Nelson 2014, 2). In the United States it was not until the nineteenth century and the widespread installation of indoor plumbing that this practice of composted human excrement as fertilizer grew out of favor (Nelson 2014, 4). According to Mark Nelson, proponent of composting toilets and black water recycling, while many regard indoor plumbing as the “...mark of a civilized society and the solution to epidemics” that plagued society before its invention, he views indoor plumbing as a part of “The Law of Unintended Consequences” and considers it mostly as “...the height of insanity to use drinking water to dispose of human waste and then wash it away...spreading the potential for pollution of all Earth’s water bodies” (Jenkins 2014, 6). In the nineteenth century the notion of the “Solution to Pollution is Dilution” became popular, which in many



cases has now been proved wrong by composting advocates. Tony Juniper, Author, Fellow at the University of Cambridge, and Advisor to the Prince of Wales in regard to this matter states “...there is in many cases a better way, one that brings not only health and sustainability but, also beauty. Infusing it all is the realization that nature does not waste and if we wish to endure, then neither should we” (Nelson 2014, iv).



<http://afristarfoundation.org>

The flushing of human waste down the drain of course often contributes effluents into our drinking water and fresh water supplies as explained in the preceding section. Primarily because as waste water facilities also treat chemicals that are disposed of down the drain or through storm drains, it is that chemical contamination and lack of composted material that makes the resultant sewage sludge a toxic material- not necessarily the human waste itself (Nelson 2014, 57). It is said that we are what we eat, and while uncomposted manure can cause diseases such as cholera, typhoid, and diarrhea, generally pathogens are a concern in humanure if the maker had diseases themselves (Nelson 2014, 7, 44). Being a direct “waste” product of our diets, humanure itself on average contains 5-7% nitrogen and 3-5% phosphorus of which both are essential nutrients needed for proper and healthy plant growth and crop production (Nelson 2014, 8). This composition of minerals and nutrients however, while being very beneficial in the composted, land applied state, is seen as a detriment in the uncomposted form or when the human waste is directly discharged to water bodies. As a result of this practice, as new evidence suggests, uncomposted human waste is believed responsible for increased algae blooms thus reducing the aerobic conditions in water bodies, and due to the increase in available nutrients, the resulting overall decline of our coral reefs (Nelson 2014, 76).

Composting of human waste is therefore important for plant and soil fertility and the ecology of our lands. “Night Soil” as it is called is the mixture of approximately 70% crop residues and food scraps, 20% manure, and 10% soil (Nelson 2014, 21). The mobilized nitrogen found in the organic matter of the crop residues produces heat which allows the minerals in the humanure to break down into their nutrient states, thus becoming available for plant growth. One tool utilized to effectively and easily compost human waste is composting toilets.

Composting toilets are therefore closed unit collection devices that break down solids in human waste over time. They can look like a conventional toilet but are instead water free and requiring of access to the composting compartment below the toilet itself. They also have venting systems and organic matter is kept nearby the toilet to spread over the solids to limit waste odor (Jenkins 2005, 115) (Figure 12- 14).





Figure 12  
<http://www.motherearthnews.com>



Figure 13  
<http://www.ecoterra.com>



Figure 14  
<http://www.compostingtoilet.com>

## Earth Sheltered Houses

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When people think of earth sheltered houses, for some an idea of “Hobbit Houses” is what comes to mind first (Figure 15). Often to these same people the thought of living in an earth sheltered house is considered to be their “worst nightmare.” This said “torture” might be related to the uninformed notion that the interior space is overwhelmingly tight and thus promotes fears of claustrophobia, that the home would suffer from a dramatic lack of light, and that we as members of the top of the food chain belong above ground and not below with the animals, insects, rodents and other perhaps mythological earth dwellers. The idea when presented to other people sometimes brings to mind bunkers, fallout shelters, caves, and earthships.

There do exist, however, many examples of earth sheltered buildings that are not dim hobbit houses, and that instead offer an abundance of light and a huge amount of interior space- often of which is considerably more than that compared to conventional house construction. One such example of an underground dome structure, is the National Botanic Garden of Wales (Figure 16). This structure interestingly holds the most endangered living plant species on the planet and is the largest single span greenhouse in the world. Other large and well lit earth sheltered projects are Malatour, in Wales (Figure 17), and the Bolton Eco House in northwest England (Figure 18). As we will explore, many earth sheltered buildings and houses exist in European countries, notably England, Germany, and Switzerland.



Figure 15  
<http://www.hobbitouse.com>





National Botanic Garden  
Wales

Figure 16  
<http://www.gardenofwales.org.uk>



Malatour or Project 22  
Druidston, Pembrokeshire, Wales  
Built 1998: Future Systems

Figure 17  
<http://www.decoist.com>







Figure 18

<http://storiesofhouses.blogspot.com>

<http://makearchitects.com>



### Bolton Eco House

Northwest England; Built into hillside of Mt. Pennine

Built 2009: Make Architects

9,000 sq ft; 4 bedroom; 1 story

Known as the “house of the future”

Generates wind and solar

## Terminology

The term Earth Sheltered House and its visual manifestations mean different things to different people.

Some people consider Underground Buildings, Earth Berms, Earth Rammed Houses, and Bunkers as all falling under the Earth Sheltered umbrella. According to the U.S. Department of Energy, typically houses built below grade or completely underground are called underground structures and they are usually built around an atrium or courtyard to let in natural light (U.S. Dept. Energy 2013, 2). Houses built above grade or partially below grade with earth covering one or more walls are called bermed earth sheltered homes (Ibid). These structures usually face south, have an exposed glass façade to allow light and heat inside, are best for hillsides, and often are the least expensive option for earth sheltered housing (Ibid).

## Malcolm Wells

There exist cases however, where the ideal southern exposure and maximum passive gain is not met, and the exposure was orientated to a different direction intentionally or because the southern exposure was not possible.

One such case of deliberate alternate aspect is the private home of Malcolm Wells located on Cape Cod. Wells, whom many regard as the grandfather of earth sheltered and underground building and who is probably its best known proponent, designed his Cape house to have no southern orientation, but rather long sides facing the east and west, only out of a desire to see the grand views (Lyle, 1994, 117) (Figure 19). Instead of passive gain he relied upon the regulating temperature of the earth to provide heating and cooling of the interior spaces (Ibid).

Earth sheltered building, or underground building as Wells calls it, is “silent, bright, dry, sunny, long lasting, easy to maintain, easy to

heat and cool, and fire safe” (Wells 1998, 3). As shown in one of his many books, his often fantastically, very futuristic looking designs, are surrounded by topography on mostly all sides but one, and even blend into the landscape by having the roof seamlessly flow into the surroundings.

Wells again states “[I became an underground architect] because we’re so quickly paving everything with buildings and asphalt. I became an underground architect because it’s the only way to build without destroying the land” (Wells 1998, 3).

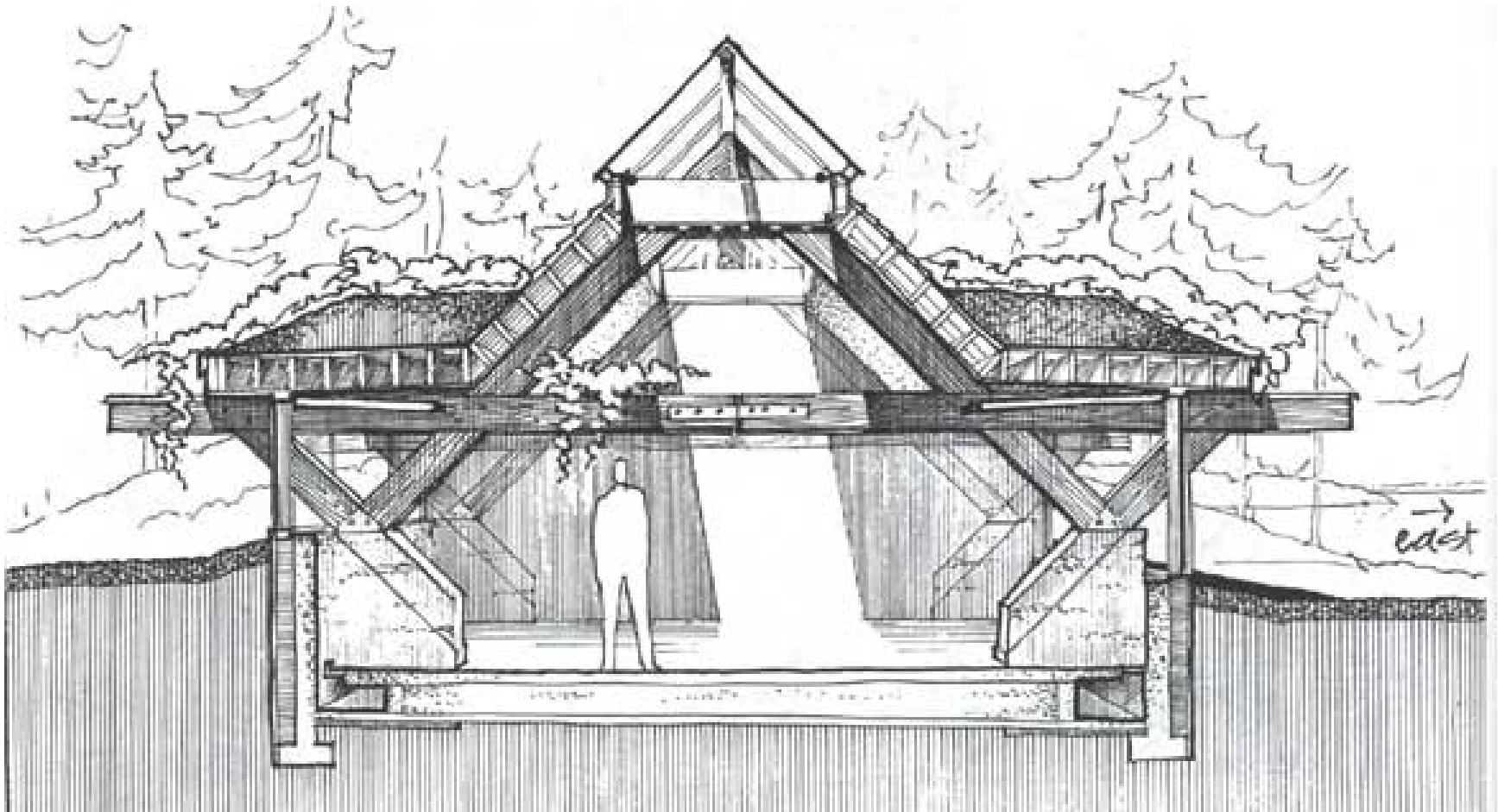


Figure 19  
<http://www.malcolmwells.com>

## Construction and Benefits

As with any building project, site specific considerations dictate construction, and a solid understanding of those limitations is necessary. Soils and water or flooding risk to the site are incredibly important considerations, and sites not suited for construction should be avoided. Well drained, permeable, granular soils are the best to limit flooding risk, and systems such as French drains built along back walls and swales graded around the structure should direct water away from the home (US Dept Energy 2013, 4).

As compared to conventional houses built above ground, earth sheltered structures offer on average 80-90% lower heating and cooling costs (Chiras, 2003), which are both primarily due to the natural insulating and cooling ability of the earth (Meijelfeldt 2003, 237). This insulating ability allows a more stable interior temperature, and in New England specifically, below the 4' frost line the earth's constant temperature is around 50 degrees (Chiras, 2003). This constant temperature in the summer and winter months then limits the temperature increment needed to reach 65 degrees, which is the typical human comfort temperature for interior spaces (Ibid). This small increment thus lowers heating costs and often eliminates the need for air conditioning. Homes sheltered in the earth are further protected from summer heating sun and cold winter winds stripping indoor heat, thus again limiting energy costs, and the potential for underground pipes and water pumps to freeze in the winter. The south facing slope is ideal but even north facing slopes can see an energy savings of 50% in winter due to passive solar gain (Ibid).

Materials of the structure are also essential to its waterproofing capabilities, and most often concrete shells or blocks are used. Typically most structures should be completely waterproof, and therefore they require careful and considerate engineering. Additionally, because roofs have to be strong to support the weight of the earth, and walls have to be solid and durable, concrete masonry units or blocks reinforced with steel bars are often used (Chiras, 2003). Many companies also offer kit homes which can be delivered, or they assist with the initial shell



construction on site. Figure 20 is an example of an 'Earth House Shell Kit' that was delivered to the house site in Switzerland.



Figure 20  
<http://www.erdhaus.ch/main>

Because of the impermeable and strong building materials, earth sheltered homes tend to resist natural disasters such as earthquakes, wind storms and hurricanes, fire outbreaks, termites, and rodent infestations, and because of this are less to insure as compared to the conventional (Chiras, 2003). As explained previously however, banks and other lending institutions often view this housing style as offering a much lower resale value so obtaining a mortgage for such house might be more difficult.

In terms of house maintenance such as re-roofing, siding, and painting, earth sheltered housing requires less upkeep than conventional homes, and ice dam issues in the winter are avoided. Instead of essentially a wasted space the roof can instead become beneficial in that it could grow vegetables, offer grazing for livestock, or support meadow habitat for increased wildlife biodiversity.

The low profile and strong connection to the landscape also make earth sheltered homes minimally disruptive to the surrounding landscape thus pleasing many earth conscious people. Creatively they too can be used for additional structures other than human housing such as storage spaces and animal barns etc. Finally, to many they offer the benefit of the most user privacy, noise reduction, and soundproofing from outside or surrounding elements (Quinn-Szcesuil, Julia, 2014). However to some, as referenced in case study number two in chapter three, this soundproofing is seen as a mild detriment especially when no pleasing sounds audibly exist from rain drops falling on the roof.

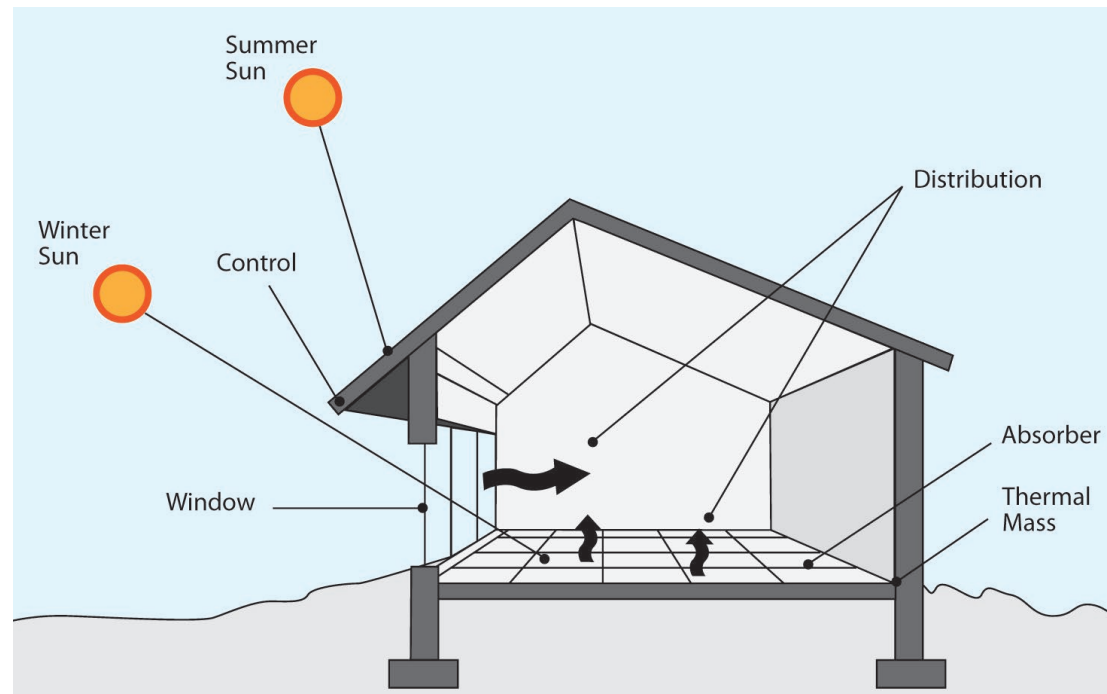
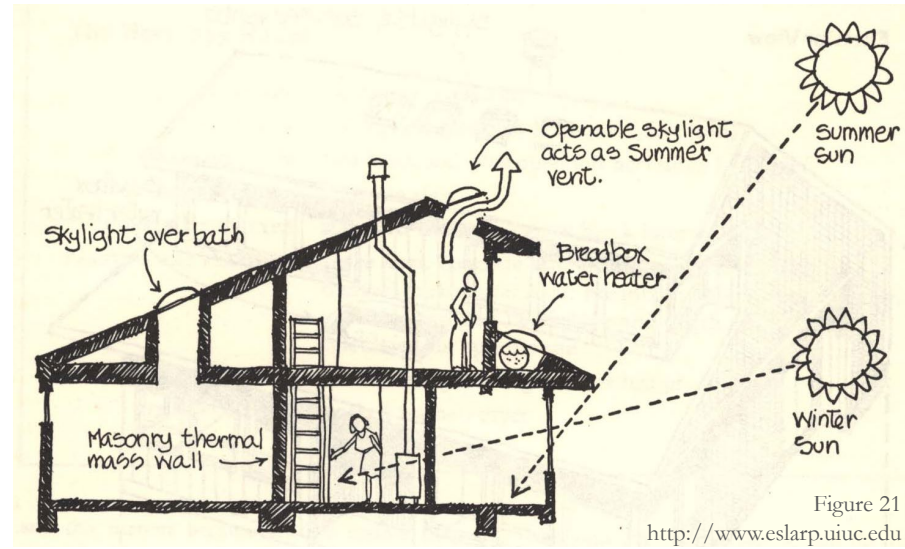
## Passive Solar Energy

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An integral part of a regenerative landscape is passive solar energy. This form of energy refers to the thermal energy flows caused by sunlight radiation, conduction, or the natural motion of heat caused by temperature gradients, which is called convection (Sustainable Sources, 2015). They essentially, through no mechanical means or moving parts, harness and use the sun's energy as a way to heat and cool the interior spaces.

Specifically when sunlight hits a building, those building materials can then reflect, transmit, or absorb the radiation from the sun (Ibid) (Figure 21). Ideally for effective passive solar gain the aspect (compass direction the feature faces) or aperture of the building should be of a southern orientation, and the construction should be built on an east to west axis. The southern face which is often primarily constructed of glass windows and doors should receive striking sunlight between the hours of nine am and three pm (or in some cases ten to two), and there should be shading techniques such as vegetation or built structures on this southern side to limit excessive summer heat but allow winter absorption (Ibid). Houses built in this manner generally should also have an open floor plan, and primary uses should be on the southern side of the house and secondary or less used elements should be on the north.

Other effective materials and techniques for passive gain are often concrete, stone, or brick which act as thermal mass walls; thermal chimneys which help enable the rising of warmer air and circulation of cooler air; and roof pond systems which allow the water to absorb and store heat energy (Suagee 2011, 54). As mentioned, the building should have southern facing glass and thermal mass materials to absorb, store, and distribute heat (Figure 22). There are two main approaches to passive solar energy, and they are Direct Gain, and Indirect Gain.





In Direct Gain energy the living space is the solar conductor, heat absorber, and distribution system (Suagee 2011, 54). The sun strikes the building or glass to which the thermal mass elements, such as floors or walls, then absorb the energy and release it later (Figure 23). This method effectively utilizes about 75% of the energy that was available from the striking sun (Sustainable Sources, 2015). Rules of thermal mass include: material should be 6" or less and should be evenly distributed in space so as not to have area concentrations but all over heat absorption; walls should be uncovered as carpets absorb moisture, cause humidity to rise, and lower effectiveness of thermal gain; masonry floors should be of a medium dark color; and lightweight walls should be of a light color to maximize reflection (Ibid).

Indirect Gain Energy allows the thermal mass to be positioned between the sun and the living space which will then absorb sunlight and transfer (by conduction) the heat to the living space. This system utilizes about 45% of the sun's energy (Sustainable Sources, 2015). One relevant method of indirect gain is the Trombe Walls which are located behind southern facing glass, and are often cement and have openable top and bottom vents to allow daytime heat to circulate into living area from behind the wall. At night the vents are closed and radiant heat warms the interior space (Suagee 2011, 54) (Figure 24).

A lesser approach is Isolated Gain which is usually implemented by the addition of a sun-room, and it only utilizes about 15-30% of the striking sun's energy (Sustainable Sources, 2015).

With all the benefits, passive solar energy is still somewhat of a rarely implemented method of heating and cooling. This could be due to the fact that mortgage companies and banks often view the resale value of a home higher if mechanical means of heating and cooling (ie: air conditioning) are available; some area building codes limit the amount of glass that can be used in a structure; and the cost of implementing the passive design is often slightly higher than that of a conventional construction (Sustainable Sources, 2015).

A regenerative landscape that effectively utilizes passive solar energy is the John. T Lyle Center for Regenerative Studies. This Center will be explored in depth as a case study number one in chapter three.

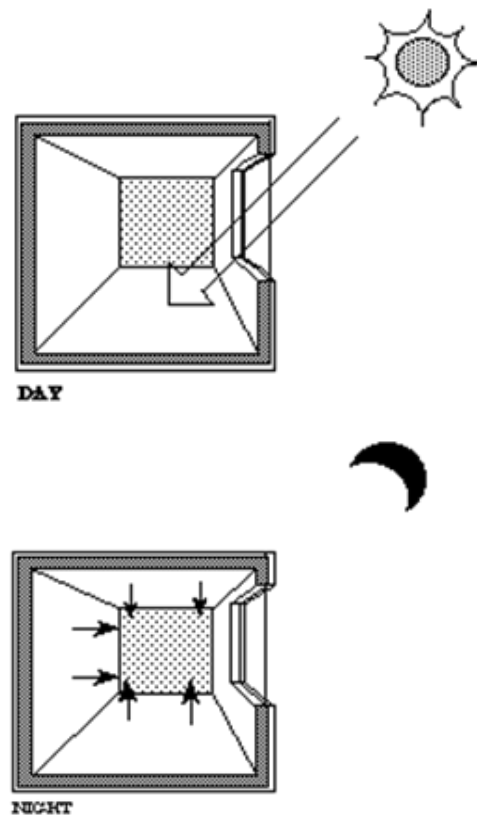


Figure 23

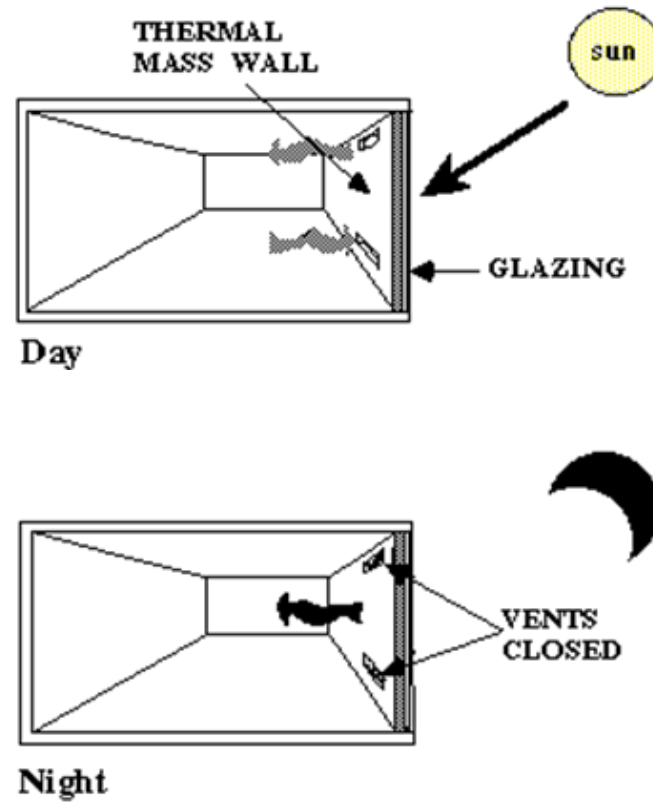


Figure 24  
<http://passivesolar.sustainablesources.com>

## Earth Sheltered Communities

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As this project is depicting an earth sheltered community, it is relevant to talk about other such communities. As it appears, most earth sheltered houses are built separated from other houses and are not centered around as a community. This practice, therefore, contributes to the lack of such built communities at this time. However according to my research, there does exist one known relevant community (Figure 25), and that, in combination with others in the design and development phases are noted as follows (Figure 26-27).



Earth House Estate  
Dietkon, Switzerland  
Vetsch Architektur  
Community of 9 houses: 650-2000 sq ft  
Bathrooms and basement stairs  
connect buildings  
Surrounds artificial lake and open land  
Subterranean parking

Figure 25  
<http://freshome.com>





Figure 26  
<http://decoist.com>

Bella Vista House  
 Bozen, Italy  
 Development phase: concept designed by Matteo Thun  
 11 hostels for Klima Hotels



Figure 27  
<http://architizet.com>



Cottages at Falling Water  
 Pennsylvania  
 Design competition won by Patkau Architects; Vancouver BC.  
 Completion date: 2020  
 6 minimally disruptive cottages on Frank Lloyd Wright property

## Other Earth Sheltered Typologies

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### Bunkers

To many other people bunkers are what come to mind when picturing an earth sheltered construction.

Many bunkers were built during and before World War II and as described by Paul Virilio, they “are the results of a philosophy of military space, the philosophy of a warlord tied to the Earth...”(Virilio 1994, 30). Between 1943 and 1944 specifically, it seemed war preparations were extremely prevalent and “everyone was advised to dig a trench in his backyard, in the courtyard, to shelter his family” (Virilio 1994, 28).

Being constructed out of very thick, solid wall concrete, bunkers appeared to not be built for many aesthetic qualities but rather for their impenetrable nature. “The function of this very special structure is to assure survival, to be a shelter for man in a critical period, the place where he buries himself to subsist...the bunker belongs too to the ark that saves...”(Virilio 1994, 46). Bunkers could be considered “one of the first known single-block architectures” (Virilio 1994, 44), and were constructed as a solid wall casing because joints and seams would only weaken the structure and lessen its protective function (Ibid). They were “...built to hold up under shelling and bombing, asphyxiating gasses and flamethrowers...the bunker was built in relationship to this new climate...its rounded or flattened angles, the thickness of its walls...the various types of concealment for its rare openings, its armor plating, iron doors, and air filters- all this depicts another military space, a new climatic reality“(Virilio 1994, 39).

This military space is still evident in the many bunkers still standing today that were built under Nazi power, and can be found in



the country sides and now forests of Europe and Germany. Ones pictured here at Kummersdorf Gottow (Figure 28) provide one example, but their existence today is not due to a design intent to house man indefinitely or withstand time, but again rather exist as an impenetrable war time survival tool. “The monolith does not aim to survive down through the centuries; the thickness of its walls translates only to the probable power of impact in the instant of assault” (Virilio 1994, 39).

Luckily, this new climatic reality of war did not last through the decades, and after threats of battle and invasions of land lessened and ceased, bunkers in large part became a relic of this war time period- “... the bunker is the last theatrical gesture in the endgame of Occidental military history”(Virilio 1994, 46).



Figure 28  
Photo: Gerard Dykstra  
<http://www.flickr.com>



## Fallout Shelters

In addition to bunkers, fallout shelters are often thought of as earth sheltered housing, and they too speak back to a war time response to fear and needs of protection.

Due to major threat of nuclear war with the then Soviet Union, and the Cuban Missile Crisis, Americans were seriously worried about protecting their families and life as they knew it. A dramatic speech made by John F. Kennedy on July 25, 1961 helped to perpetrate this fear and in a sense made people quietly panic amongst themselves (Rose 2001, 2). In the speech JFK identified his request from congress for 207 million dollars in additional funds for civil defense, told state agencies to “identify and mark out space in existing structures-public and private- that could be used for fall-out structures in case of attack”(Ibid), and warned citizens that “the lives of those families which are not hit in a nuclear blast and fire can still be saved- *if* they can be warned to take shelter and *if* that shelter is available...” (Rose 2001, 4).

At this time, common notions and sayings such as “ ‘dig or die’ and ‘duck and cover’...[were] realities for the politician, the housewife, the worker and the schoolboy” (Rose 2001, 5). Many people believed that nuclear war was going to happen, and California State Representative Chet Holifield in a speech told “in the event of nuclear war...all the people in our country are frontline soldiers...there is no frontline, no backline, the whole world is a battlefield”(Ibid).

Building a fallout shelter though became a contentious issue among many Americans. “Immediately after Kennedy’s speech questions began to multiply- questions not only about how best to protect the home, but also about whether the home *could* be protected against nuclear weapons, or even *should* be protected against nuclear weapons” (Rose 2001, 9). Speaking to my own grandmother and her friend, Janet, who actually built one, they both were extremely worried that war would happen, but were unsure that a fallout shelter would even protect against massive heat or radiation, and that if nuclear war happened what kind of world would they be coming back to after leaving the shelter. This

doubt was mitigated by advertisements that marketed the fallout shelter as aesthetic, family friendly and capable of having a nice interior similar to styles of the day; at a 1960 Chicago trade show the fallout shelter was even hailed as “the family room of tomorrow” (Rose 2001, 191) (Figure 29).

Janet’s husband built a small one sheltered in the backyard with the help of the salesman whose ad they saw in the newspaper. It was concrete block, only big enough to fit 5 people, had no shelves or bunk space, and was expensive for the time. She too remembers the neighbors being very curious about the construction, and her feeling uneasy as to when the blast was to occur would she be alone with the kids, and what if the neighbors asked to come inside, would she say no? My grandparents who were, and still to this day are farmers, built a block version in their basement and stocked it according to the suggestions in the weekly paper. My grandfather also was a builder, and he too built a real one sheltered in the earth for a wealthy local family. It is no surprise that many families, across different lifestyles, were very concerned.

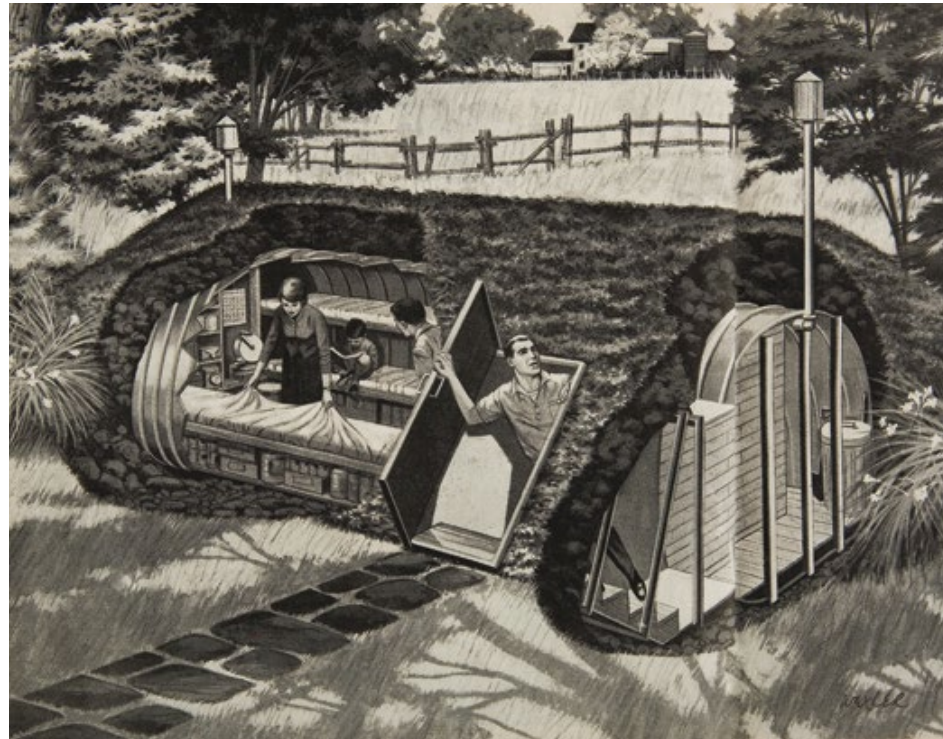


Figure 29  
<http://atomicoasters.com>

With time, tensions between the U.S. and the Soviet Union eased dramatically, and the threat of nuclear war faded. Around 1963 the urgency to build fallout shelters ceased, and it was only again briefly revived during President Reagan's reign (Rose 2001, 10). Overall, most Americans did not build a shelter or believe in the inevitable occurrence of nuclear war.

Kenneth Rose, who wrote *One Nation Underground: The Fallout Shelter in American Culture*, notes however that the main reason Americans rejected mass shelter building was to do with the moral questions and ethical aspects of having a fallout shelter (Rose 2001, 10). Like Janet, many Americans worried about neighbor relations and too questioned the notion of the bunker's effectiveness or long term sustaining ability, and doctors publicly questioned their own ethical responsibility to helping others injured on the outside (Ibid). Studies on effects of living in a bunker published that long term exposure could lead to depression, and for most American's the idea of living in one questioned their ideals of what American life should be like. "The relaxed, carefree life promised by the suburbs was clearly compromised by fallout shelters, which served as constant reminders of the possibility of nuclear war" (Rose 2001, 190) and "in order to 'preserve' the United States, would its citizens have to burrow in the earth like moles?" (Rose 2001, 10).

Kennedy himself, of course being such the proponent that he was, had at least two fallout shelters that we know of to which he could have sought refuge. The "Detachment Hotel" as it was called, is on Peanut Island near Palm Beach, Florida, and was constructed solidly out of concrete in 1961 (Alvarez, 2011) (Figure 30). It could hold thirty people, and had fully stocked shelves with additional space for fifteen metal bunks (Ibid). The government did not acknowledge this bunker's existence till 1974, and in 1999 it was opened to the public for tours. He also had another one on Nantucket Island in Massachusetts which was also built in 1961, but this shelter has never been opened to the public (Ibid).

Even though the popularity and perhaps the necessity of bunkers and fallout shelters has faded, nonetheless, they both remain an important part of American culture and "at [the] very least [they] prompted a debate about nuclear war and survival" (Rose 2001, 213). The U.S. government agency, FEMA, now does not even recommend building them, and acknowledges that fallout shelters may offer decent



protection against tornadoes and hurricanes-but they do not mention their effectiveness for a nuclear attack (Rose 2001, 224). Today the fallout shelter “is now almost universally viewed as a grim Cold War relic” (Rose 2001, 234)...except perhaps for in the minds of “preppers” or survivalists who continue to view and build these structures as and for the ultimate in home protection and family safety. This market is though a very small niche, and many structures in this style are currently for sale beacuse they are not widely popular or in demand (Figure 31).



Figure 30  
<http://www.trbimg.com>



Figure 31  
<http://disaster-shelters.net>



## Cave Dwellings

Branching off bunkers, fallout shelters, and survivalist homes, all built completely surrounded and impenetrable, leads then to cave dwellings which are both an ancient style of housing as well as representative of a modern fringe of living.

Currently in our time, there are numerous cave dwellings that are either small spaces that single families live in, or that are very large excavations that hold lodges and hotels. Beckham Creek Lodge and Inn in Arkansas is one such example of a large, more modern cave dwelling (Figure 32).

Walnut Canyon National Monument in Arizona is an example of an ancient cliff style that was built only for basic sheltering needs. These twenty-six visible dwellings located near Flagstaff were built into the face of a surrounding canyon. Out of a desire to protect the crumbling and still intact walls and surrounding landscape, these dwellings and 3600 surrounding acres are under a National Park and Monument designation. This National Park is discussed in depth as Case Study Number Four in Chapter Three.



Figure 32  
<http://beckhamcreeklodge.com>

## Pit Houses

Another typology related to cliff dwellings is the pit house. This style is believed to have been the winter housing for primitive man in the Upper Paleolithic (or Late Stone Age) time period dating to about 40,000-10,000 years ago, and it is also believed to be the oldest known style most related to the modern house (Daifuku 1952, 2).

As excavations have shown, man of this time period lived above ground in the warmer months, often in cliff dwellings, and in the colder months utilized the insulating capabilities of the earth and lived below ground. These mostly rectangular dwellings were constructed in the earth, surrounded on all four sides and had a ventilation opening in the middle roof with central fire pits below (Daifuku 1952, 3). The walls were often stone slabs or large animal bones, and the underground spaces were sometimes very large which led anthropologists to believe that they supported a communal style of living (Ibid). Some of the largest excavated dwellings have been underground spaces thirty five meters long by fifteen meters wide (about 115 by 50 feet).

Additionally, since this style of dwelling existed around the world for thousands of years, it naturally varied among peoples and geographical conditions. Depending on the tribe and area, some are believed to have used a side entrance in the summer, and the central opening with a ladder in the winter, while others used underground entrances and only used the central opening for ceremonial practices (Daifuku 1952, 4). In North America, based on numerous sites that have been excavated, two major types of houses were believed to have been built, the Ipiutak or “Alaskan” house and the “Arctic Whale Hunting Culture” (Daifuku 1952, 5). These styles had variations however, but basically the Alaskan house was a subterranean square with rounded corners, about five meters long on a side, the center had a fire pit, the walls were logs and the roof formed a truncated pyramid with side entrances (Ibid). The Arctic Whale Hunting style had heavy sod walls which supported the roof, a sunken entrance passageway with recesses, no cooking pits because they burned seal oil, and also had a rear porch

like structure (Ibid). This style is thought to have been warmer than the Alaskan houses.

Further, through excavation efforts many believe that pit houses are the oldest style of housing construction known to man. In the United States it is logically assumed that variations on them existed across the whole country and that as a result, “there is every reason to believe [that for] any...early man, [when the] habitation site is discovered the domiciliary structure will be the semi-subterranean [pit] house” (Daifuku 1952, 7).

Because of their earth friendly aspect and ample light many modern interpretations of the pit house have been built (Figure 33).



Edgeland House  
Austin, Texas  
Designed by Bercy Chen  
Architects Studio: 2012  
1,400 sq ft  
Built on former brownfield

Figure 33  
<http://inhabitat.com>



## Icelandic Turf Houses

One more example of an ancient style of house construction is the Icelandic Turf House.

Variations on the construction of these too, existed over time and across societal class designations. At their heart they are structures completely covered in earth. Primarily they were made out of turf that was cut into brick like forms that were then stacked to make the walls. These bricks were stacked on top of a fieldstone like foundation or small knee wall which helped with stability and providing an outlet for water to exit the structure (Short, 2015).

Starting in the 10<sup>th</sup> century these structures (or 'Long Houses' as they are sometimes referred) had very large rooms with high ceilings and capabilities of being added on to. This is evident in the recreation of a long house in Strong that was destroyed by ash in 1104. During this time wealthy Vikings were able to procure timber or driftwood to make the walls, framing, and ornately carved doors; the poor were forced to use only turf (Ibid) (Figure 34).



Figure 34  
<http://www.hurstwic.org>

In the 18<sup>th</sup> century a new style appeared called Burstabaer. These had wooden ends and often interconnected buildings under the turf roof and walls (Northern Lights Iceland, 2015). These houses resemble small coastal cottages and have small windows, and now in modern times, are painted bright colors. This style is a referenced typology for this project's housing community.

In the 19<sup>th</sup> century, as it is well known, there was virtually no wood left in Iceland to build with or burn for heat. As a result, houses were instead built much smaller, had minimal wood elements, and were comparatively very cold and damp due to the fact that they were now heated with animal dung (Short, 2015).

While some original structures still exist, many of the turf houses seen in Iceland today are recreations and rebuilds of originals. The previously mentioned recreation at Strong is one example, as well as the Hofskirkja Church, which is now considered the last turf church in Iceland. It was originally built in 1343, and it was rebuilt to the current style in 1884. (National Museum of Iceland) (Figure 34).



Figure 34

<http://ethandthornphotos.files.wordpress.com>

## Earthships

Earthships are the final earth sheltered typology discussed in this paper, and they are perhaps the most different. For modern day sustainable housing proponents, when thinking about earth sheltered housing, earthships are instead what precisely come to mind.

Earthships are largely earth rammed houses built with recycled materials, or materials that would otherwise be considered as waste or trash. The concept was born out of the “principle of the problem being the solution” and as a way to solve the problem of having “too much litter and too little affordable shelter” (Harkness 2011, 57). It was conceived by architect Michael Reynolds in the 1970’s, and most earthships can be found in Taos County, New Mexico (Harkness 2011, 58). Today in the New Mexico area there exist about fifty built earthships, but more new constructions are planned; they and other earthship inspired designs are also gaining popularity across the U.S., Europe and Africa (Harkness 2011, 55).

Specifically the otherwise considered trash materials used to make earthships are: old tires, glass and plastic bottles, aluminum cans, and cardboard (Earthship Biotecture). Architectural salvage materials are used for windows, doors, floors, tiles, and cabinets; industrial by products such as sands and gravels are also used to help make the plaster and concrete (Ibid). Primary building blocks of the walls are the tires which are filled with pounded earth (Figure 35). These ‘Rammed Earth Bricks’, as they are called, on average number at about 430 in each home, and they are plastered over so a smooth interior wall finish is visible (Ibid). The flexible yet solid nature of the tire is considered both good for earthquakes and indestructible. In terms of the off gassing of the petroleum based, chemical laden tires, proponents believe it is a “non issue” and that “tires are hazardous in piles, not earthships”(Ibid).

The other building blocks include the ‘Little Bricks’, which are the various aluminum cans, and glass and plastic bottles. These bricks are left visible to the wall surface, and sunlight passes through them projecting and illuminating their variety of colors (Ibid).



Because of the nature of the materials each earthship is unique, and no two are exactly the same (Figure 36). This uniqueness is appealing to many, and in combination with the eco-friendly aspect they are especially appealing to those who truly want to live a sustainable life. Most who build earthships also intend for them to work in conjunction with other forms of self sufficient sustainability like solar and wind power generation, organic gardening and food production, rooftop water harvesting and recycling of graywater. Plumbing and cleansing systems in place support the reuse of water, which is part of the “zero waste approach” that is central to the earthship concept (Harkness 2011, 58). Those who live in earthships take on the “sometimes unpleasant task of dealing with their own waste, and acknowledging their responsibility for it” (Harkness 2011, 64).

With new technologies come new approaches to sustainability, and earthships are considered an “evolving architectural experiment” (Harkness 2011, 58). This experiment is too “a tale that speaks of the potential of, and the increasing need for this kind of creativity in times of rising ecological consciousness” and one that attempts, head on, a creative way to handle and manage all of the waste and dwindling resources of the world (Harkness 2011, 64).



Figure 35  
<http://earthship.com/construction-materials>



Figure 36  
<http://media.cmgdigital.com>





Photo: Michael Davidsohn



## Chapter 3: CASE STUDIES

### The John T. Lyle Center for Regenerative Studies

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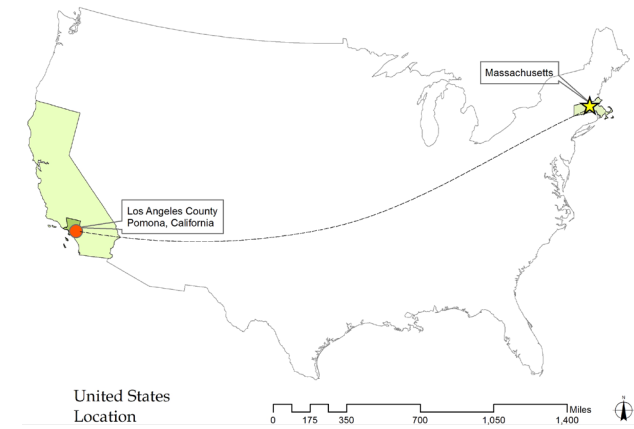


Figure 37

Data: <http://egis3.lacounty.gov>

As previously mentioned, the Lyle Center as it is also called, is a great case study for a truly regenerative landscape that also educates and employs passive solar energy methods.

Having to do with John Lyle’s “hope for the future”, this center set on sixteen acres on the campus of California State Polytechnic University in Pomona, California, (Figure 37) serves twenty full time residents and regenerative study students. It first became an idea in 1976 out of the questions “how will a regenerative community function, and what would life be like living in one”, and became a reality in 1993 (Lyle 1994, 15). Lyle was a Landscape Architecture professor and he “challenged students to envision a community in which daily activities were based on the value of living within the limits of available renewable resources without environmental degradation” (Cal Poly Pomona, 2015). The mission of the complex is “to advance our understanding of environmentally sustainable living through education, research, community outreach and demonstration”, and the primary focus is sustaining a research and teaching facility that allows students to explore

regenerative techniques and sustainable concepts as a way to solve modern environmental problems (Ibid). The campus offers both a minor and a Master's of Science Degree in Regenerative Studies.

Going back to Lyle's triangle of regenerative principles, education and demonstration are a large part of the Center's focus. The campus itself is a carbon neutral living laboratory that supports one of the last stands of Southern Black Walnut in the state, encourages student trials and research which is evident in many building method and construction prototypes seen on site, and actively partners with community outreach and local organizations to encourage and educate about organic and sustainable community gardening techniques and innovative outdoor cooking practices (Ibid) (Figure 38).

Part of the outreach and building trials is The Center's *Habitat 21* which currently is focusing work in Mexico, and is primarily a project that supports healthy communities and sustainable housing developments for poverty stricken areas. Pictured here is a *Habitat 21* papercrete building prototype designed by a former student (Figure 39), and another building prototype utilizing Trombe walls (Figure 40).



Figure 38



Figure 39



Figure 40

All photos: Michael Davidsohn

Specific features on the site include integrated organic agriculture and aquaculture systems, community kitchenettes, recycled waste water ponds and water utilization (Figure 41), engineered buildings designed to maximize heating and cooling inputs by using more natural energy flows (Figure 42), passive solar, seasonal sun patterning, shading techniques, and solar and wind power (Ibid). The center is terraced, and the solar aspect of the buildings is primarily of a southern exposure. Although some buildings face multiple directions, the majority of all windows are facing south (Figure 43). Lyle recognized that the sun is at a more vertical direction in the summer and more at a 45 degree angle in the winter, which is why he designed vegetated trellises along the southern exposures (Lyle 1994, 138) (Figure 44). These trellises support annual vines which help shade interiors in the hot, summer California sun and allow sun penetration in the mild winter. Air flow and ventilation are thoroughly considered in the building styles as well, as buildings all have openable windows and vents, and some have top vestibules or thermal chimneys with clerestory windows that allow the warmer air to rise and escape while the cooler air circulates below.



Figure 41



Figure 42



Figure 43

All photos: Michael Davidsohn



Of additional note is the implementation of multiple pathways of regeneration (Figure 45). No single tool is evidenced here, and space that can be utilized for regeneration is dedicated for that use and not wasted by being empty space (Figure 46). The uses of the space often change though over time, and this changing is an integral part of the regenerative landscape. Changing uses are evidenced by prototypes left in a prior state of construction, landscape areas that are un-programmed and in the midst of construction, and some solar panels that are on wheels designed to be moved with the changing sun.

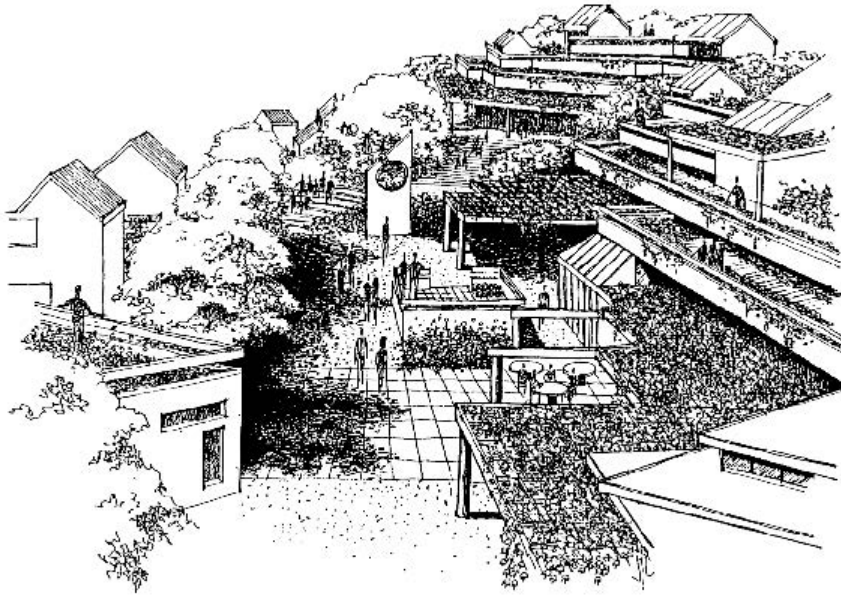


Figure 44  
Photo provided by: Dana MacDonald



Figure 45-46  
Photos: Michael Davidsohn



Some issues with the Lyle Center apparent in a study of site photos and website research are perhaps a lack of modernization to its features and building designs, funding discrepancies, and a possible decline in student commitment or desire to live in the center.



<http://www.cpp.edu>

Lessons Learned Applicable to Chosen Site:

**A community can function based on regenerative principles:** A community could exist anywhere there is local support.

**Modernize this concept:** Integration of this with earth sheltered houses could help elevate this concept to an accepted and popular alternative to the traditional. Modernizing the designs would possibly be more appealing to markets.

**Multiple regenerative pathways are required:** In order for sustainability and regenerative principles to be completely effective, multiple pathways and avenues of energy production, recycling, crop production and harvesting, construction and innovation must be achieved.

**The terraced and sloping hillside is ideal:** Gravity fed systems are more sustainable than pumps and recycling of water on the large scale is possible, terracing allows the most effective irrigation, thermal mass potentials, topsoil protection and more sustainable cut and fill.

**Natural air flow patterns reduce heating and cooling costs:** Design windows so interior temperatures can be regulated; ample windows on the south are ideal, east and west are also desirable.

**Construction can be simple:** A variety of different and low cost materials can create effective and lasting shelter and community feel.

**For perceptions to change, buildings and landscape should fit local aesthetic:** Blending regenerative techniques and earth sheltered elements with the existing landscape aesthetic is necessary to embrace the community and encourage support.





Photo: Chuck Linton



## “The [Ideal] Bunker”

---

A good case study for earth sheltered houses is the home of Chuck Linton and Lori Leinbach in Southborough, Massachusetts (Figure 47).

“The Bunker”, as it is called by the residents, was built in the 1980’s by the contractor owner; Linton and Leinbach have lived in the home since the 1990’s and are now the third owners. The house itself is sheltered on three sides not including the roof, and has a southern aspect with an almost complete glass façade, thus allowing excellent passive gain. Upon my visit to this home on a cold winter day the interior was comfortable in temperature at around 70 degrees, and Chuck noted that even in power outages the interior temperature never goes below 55 degrees.

The house is a two bedroom, two bath, two story, 2000 square feet, open concept structure constructed primarily of concrete. The earth sheltered, thermal mass walls are two feet thick, and an air handler runs constantly circulating air through several eight inch hollow concrete planks overhead. These planks run from the front (south) to the back (north), as do four load bearing steel I beams that support the soil and grass laden roof. The solid concrete shell construction is protected from water penetration also by a thick rubber membrane which sits between the concrete and a thick depth of gravel that is then next to soil. Because of the solid construction and rubber membrane, there have been no issues with water seepage in the house, and mold has never been a problem partly due also to the de-humidifier that runs in the summer. In addition to the passive gain, the homeowners have a gas heat fireplace in the living room and a heat pump which circulates heat downstairs into the bedrooms.

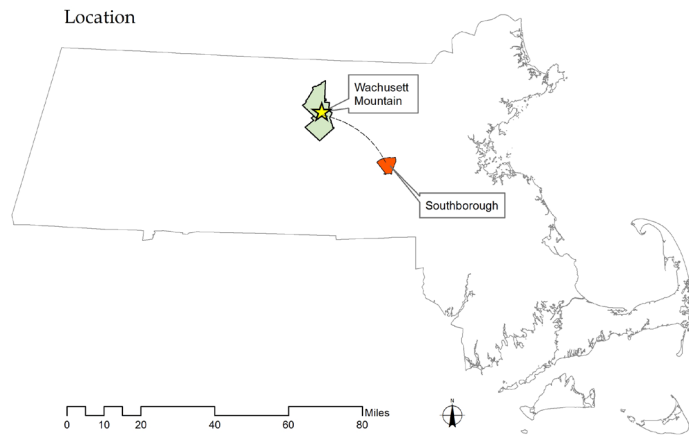


Figure 47  
Data Source: Mass GIS

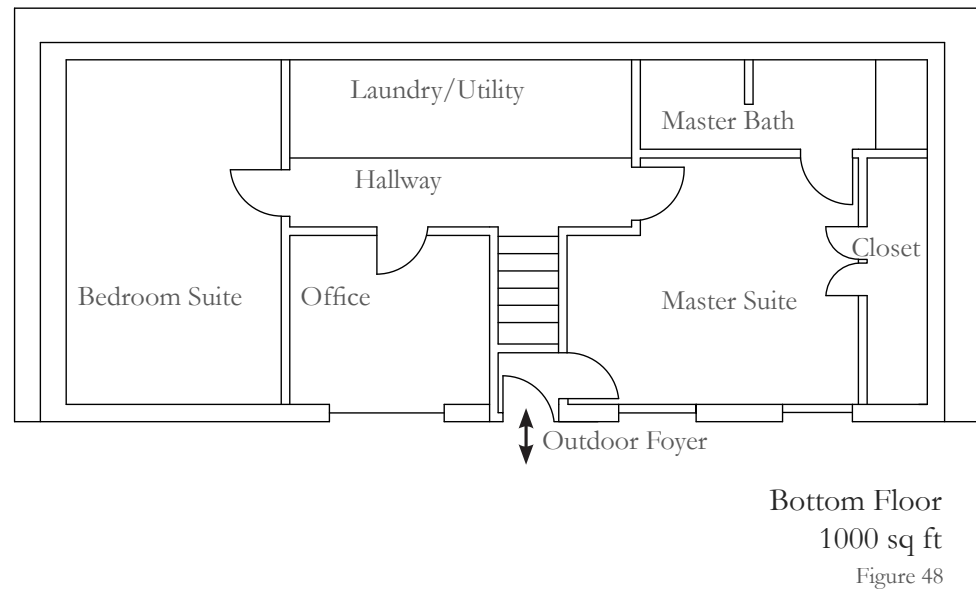
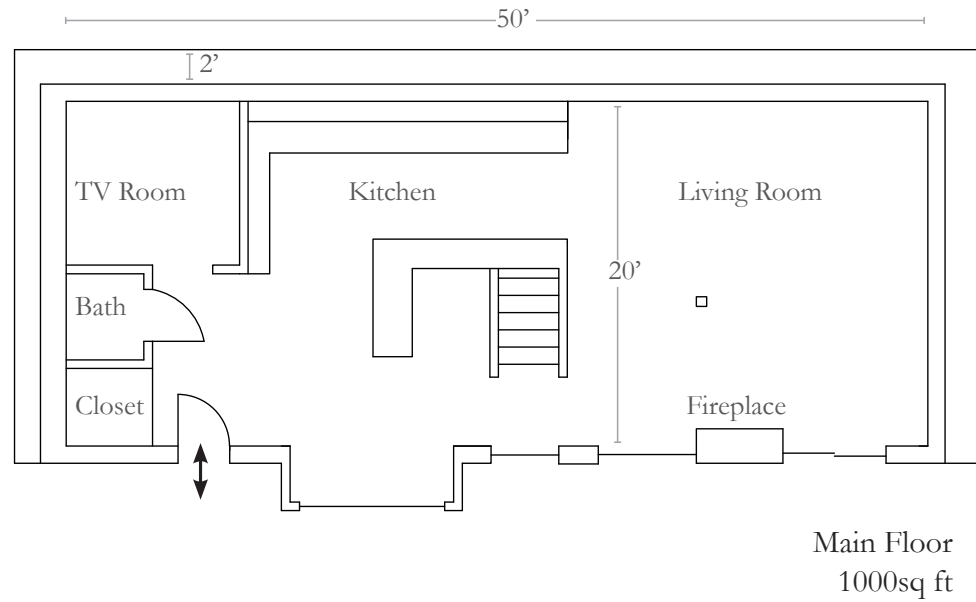


Figure 48

The interior floor plan is primarily an open concept, and the main uses of the home are along the south wall (bedrooms, office, living), and the secondary uses (laundry, utility, bathroom) are along the north (Figure 48). Walking into the house brings you into a bright eat-in kitchen/ dining/ living space, and a set of central stairs then brings you down to the bedrooms, laundry and office space (Figure 49-54).



Kitchen



Dining and Living Room



Dining and Living Room

Photo: Tom Rettig



Master Bedroom



Master Closet



Master Bath

Figures 49-54



The outside space of the house is of a naturalized aesthetic, and ample in ground growing and planting space is available. Access to the garage and house roofs are achieved by walking across the driveway, up the side slope, and then around. The garage roof is used for vegetable plots; the house roof is planted with some native grasses and is mown a few times a year. The soil on both roof surfaces does not support deep rooted vegetation, and the house roof also has to provide access to the ventilation pipes and radon monitoring equipment. Thick deciduous tree cover limits roof top solar generation except perhaps on the garage.

Some potential issues with the house are as follows: interior storage space is at a premium, the bisecting stairs, and lack of closet space have been of minor issue to the residents. From the outside accessibility to the house is not universal, but grading changes to the landscape could help remediate the issue. Being built into an existing hillside the driveway is steep, and there is a five step entrance to the home. The hillside does however allow effective earth sheltered thermal gain; the deciduously wooded front yard both cools the interior in the summer, and allows sunlight penetration in the winter, but again does not allow great solar panel generation. Because of the solid concrete construction there is no potential for any direct additions. Obviously, structures can be built next to this house as lot space permits, as was the case for the garage which was built years later trying to match the original look of the house.

In all, the house on this cold day was very warm and exceptionally bright due to the sunlight passing through the southern facing, large, floor to ceiling windows, and the reflection off the primarily white interior walls. The interior decor was very comfortable and appealing, and being inside one would almost never know it was sheltered by earth on four sides; it is by no means a claustrophobic or dark house. The owners overall love the uniqueness and earth friendly aspect of this house, and like feeling that they are doing their part for the environment. Chuck Linton also noted how other people love visiting their home, and that in power outages neighbors come over because theirs is the warmest around.



Lessons Learned Applicable to Chosen Site:

**Natural light from a southern exposure is ideal:** North, east, and west facing walls with no windows do not pose a detriment. White interiors make the house bright; an open concept helps maximize the space and light flow. Interior cutouts can open up a load bearing wall.

**Design a single story:** Owners wish this home was one floor. Five step entry is too much; staircase leads to downstairs bedrooms, office and laundry which is inconvenient. It would be better to have a single floor space, have small flights, or have secondary uses down stairs.

**Connect the garage:** Slopes pose a winter hazard- it would be better to provide a connected parking space.

**There is a market for this style:** People remark how comfortable the space is, and the owners often host popular neighborhood gatherings. From owner feedback, there could be a definite market for this style, especially among eco-conscious people.

**House can be naturally very comfortable and warm:** Being inside myself, I never felt claustrophobic or half underground. Passive gain makes the interior warm even in cold temperatures. Lack of exterior maintenance is appealing; the interior storage space is lacking.

**Provide easily accessed back yard space and interior storage:** Access needs to be easy. Thick deciduous tree cover does not allow effective roof solar panel generation, and annual, vegetated screens should be provided. Covered shelter from the rain could be considered.

**Design architecture with add-on potential:** The concrete shell prevents additions.





## Sheltered South Eastern

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While ideal situations exist for building an earth sheltered house certain landscapes present challenges, and other tools can be utilized to make the typology effective. This case study presents some of those challenges and modified tools for effective earth sheltered construction.

Driving on Bay Road in Belchertown about midway to Route nine, there is a house built into the high stream bank that you would never know was there (Figure 55). The house was built in the 1970's and the current rental residents, Jesse, Jackie, and Nick have resided in it for three years, and overall love how unique it is. The day I visited was cloudy and in the mid forties, and the air inside the house was chilly. The tenants expressed that the interior is always cold, and therefore slightly unappealing in the winter, but appealing in the summer.

This house is a one story, two bedroom, one bath, about 800 square feet concrete construction with wood exterior. It is sheltered by earth on two sides (west and north) not including the roof, and is exposed on the east and south. The aspect is southeast; it has windows on this side as well as a few on the east, and one additional light well ventilation window on the north. This house has propane heat, and it has had issues with water damage and mold. The heat is not from a centralized source, but it instead runs from the west wall to the east through an overhead concrete shaft. The southeastern façade has three all glass doors and multiple windows that you can feel a draft through, and the east side also has four windows that probably need to all be replaced. This undoubtedly contributes to heat loss, and the tenants try and mitigate these effects with heavy curtains where possible. On the north wall in the kitchen there also is a small window which is there for ventilation purposes. This window lets some light in through the shaft up to grade and has a direct view of the concrete construction wall. (Figure 56).

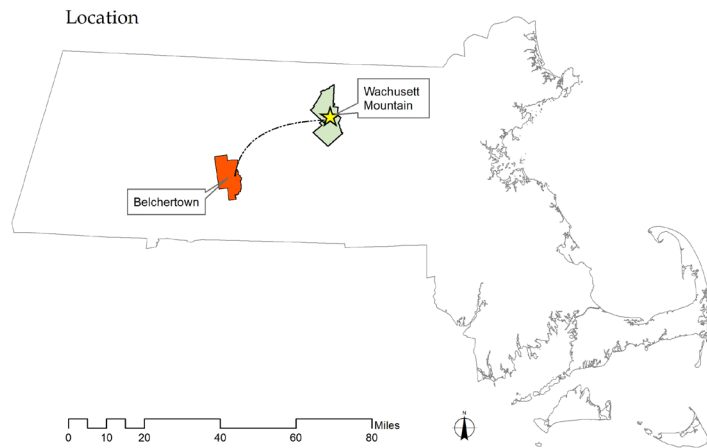
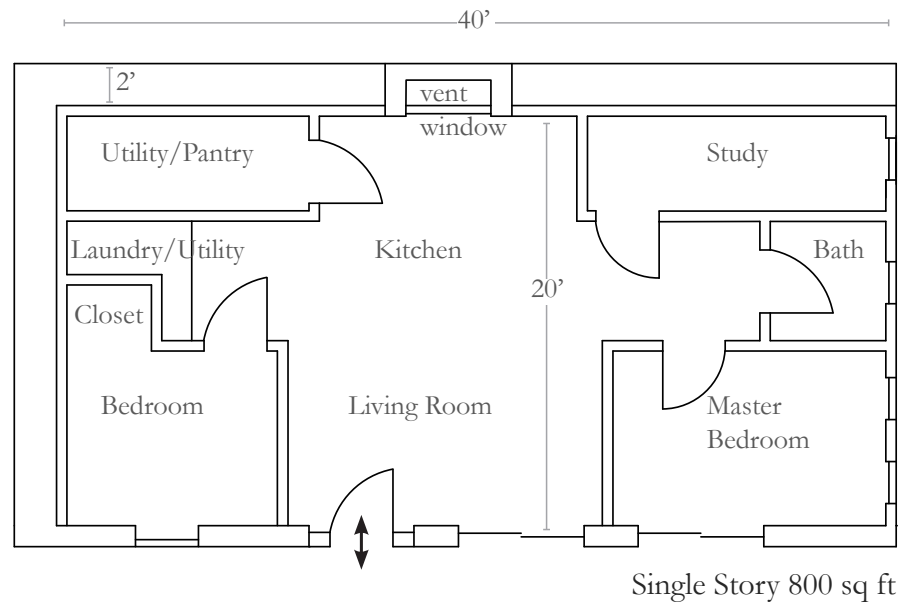


Figure 55  
Data Source: Mass GIS



Figure 56



Single Story 800 sq ft

Figure 57

The main layout of the house makes sense and is quite comfortable. Walking in leads you into an open concept, large living and kitchen space with a seating island. The bedrooms are at the west and east front ends, the bathroom is on the east end, and again, the utility and secondary uses are on the back north wall (Figure 57).



Kitchen/Living Room



Living Room



Master Bedroom



Figure 59



Issues with the house are as follows: accessibility to the house is poor due to the five foot drop from the road and an exceptionally narrow set of steps leading down to the home (Figure 59). The housing footprint in the stream bank makes outdoor space limited, mostly inaccessible and also unstable, which is why there are two main concrete retaining walls around the house. These walls too, contribute to the lack of soil planting or garden space for the tenants, and even raised beds which the residents have tried to adopt, require more space than is available (Figure 60). The previously mentioned space on top of the house could be utilized for raised beds, but its location being in the front yard of the neighbors house does not offer much privacy for the tenants. The gravel driveway is excessively large, and it takes up the majority of the front yard space.

All things considered, the tenants believe that “if this house was built today it would be better” and for these aforementioned instances that probably would be an accurate assumption. They like many aspects of this house and especially identify with its, again, unique and earth friendly nature. Not changing much about the existing construction or initial interior layout, but instead installing some replacement windows, possibly a new heat source, and some new landscape grading and design, this house could offer a much greater overall living experience. Additional interior space though would be welcome to hang out and play music as these tenants do, and for storage as there is no basement. An exterior shed or building could be useful for storage of outdoor tools, equipment and gardening supplies.

In testament to Jesse, Jackie and Nick, the overall friendly feel, relaxed atmosphere, and earthy artistic décor of this house definitely makes it much warmer than the temperatures actually support; it is pretty evident and unsurprising that people too like gathering and living here.



Figure 60

#### Lessons Learned Applicable to Chosen Site:

**Natural light from a north, south, and south eastern exposure is okay:** This house still has a high amount of light. The forested stream bank lessens the available light for the house. The north ventilation window might help with light, but its placement, looking at concrete is unappealing. Windows on the east definitely help with air circulation and light penetration.

**Provide good accessibility:** Access from the outside is an issue especially in spring and winter seasons.

**Have ample outdoor space:** Thick concrete shell and retaining walls to keep the house from sliding into the stream bed limit ground planting space. The driveway is excessively large, overwhelming to the site, and takes up valuable ground planting and garden space. Private outdoor spaces either face the road or the neighbors' house. House is within 100' regulated, and 200' ideal stream buffer.

**Open concepts are best:** Even-though the outside is cramped and small, the open concept interior is friendly. A lack of storage space is obvious, and hidden storage must be added for a house like this to appeal to more people. The residents entertain and it is a very popular spot.

**Design a modern house:** As the residents observed, 'if the house were built today it would probably be better.' Decent windows and doors need to be installed to lessen heating losses, and a better, more central system of heat circulation and burning should be implemented.





<http://1.bp.blogspot.com>



## Walnut Canyon National Monument

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Earth sheltered and cliff dwellings are by no means considered a new human habitation type as evidenced by the partially intact cliff dwellings at Walnut Canyon National Monument.

This monument is located about eight miles southeast of Flagstaff, Arizona, and in addition to the still standing twenty-six ancient cliff dwellings, the park also offers protection to about 3600 acres of relatively undisturbed and ecologically significant features (Wikimedia Foundation Inc. 2014) (Figure 61). These features include geological outcrops, rare and endangered wildlife species, and a variety of undisturbed forest and natural vegetation including the largest stand of ponderosa pine forest left in the country (National Park Service, 2015). Walnut Canyon was previously managed by the U.S. Forest Service but has been a National Park since President Woodrow Wilson dedicated it in 1915 as a way to preserve the “prehistoric ruins of ancient cliff dwellings” and surrounding natural features, and the park now sees about 100,000 visitors each year (Ibid).

Because of ancient artifacts found, it is believed that this canyon was a site of habitation dating back to thousands of years ago, but the first permanent and longest known settlement was by the now named Sinagua people who lived in the canyon from 600 A.D. (C.E.) to about 1400 (National Park Service, 2015). These people were so named from the Spanish term for the Flagstaff region, translated to “mountains without water.” They are believed to have farmed corn, beans, and squash on the fields of the rim for many centuries before they constructed the limestone dwellings that are still visible today (Ibid). They supplemented their food with wild vegetation and game for many centuries, and due to unknown reasons later relocated.

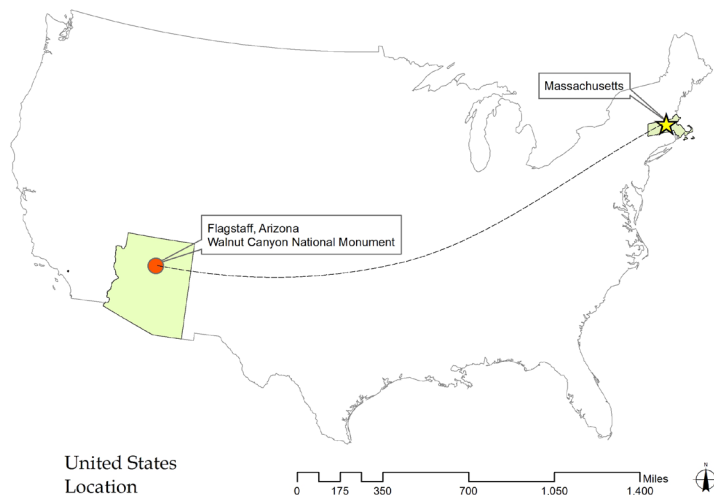


Figure 61  
Data Source: Arizona GIS- <http://catalog.data.gov>

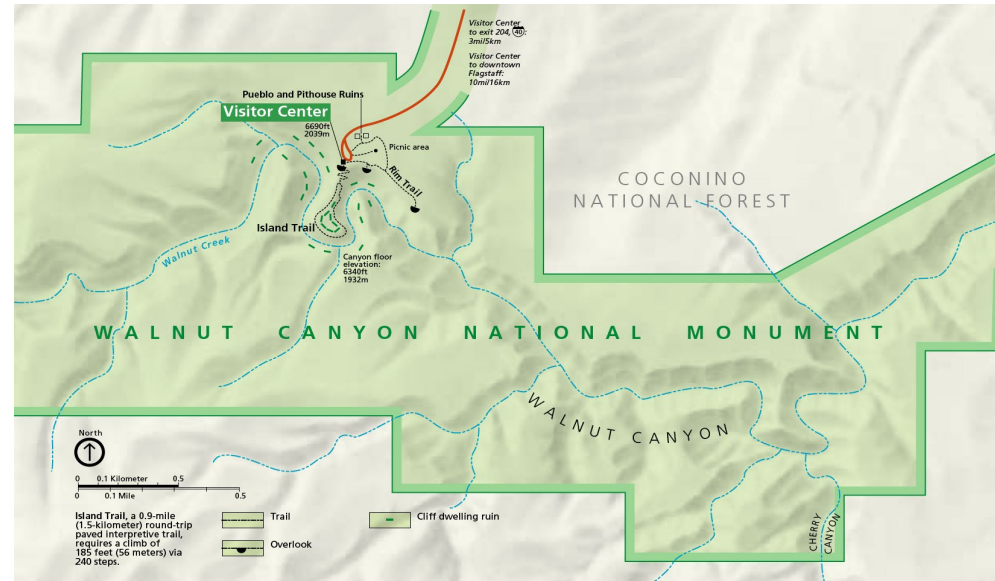


Figure 62  
<http://www.nps.gov>

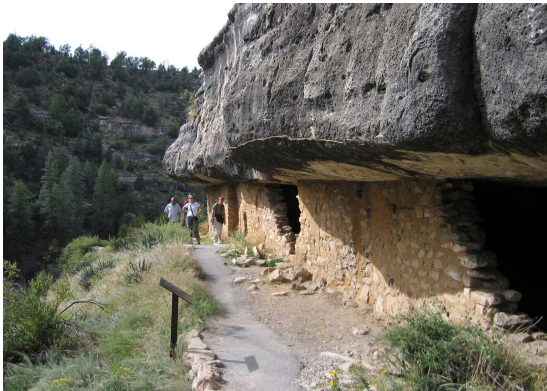


Figure 63  
<http://4.bp.blogspot.com>



Figure 64  
<http://media-cdn.tripadvisor.com>



Figure 65  
<http://arizonaexperience.org>

In a region otherwise dry, Walnut Canyon provided a unique and intelligent site for early habitation. For approximately six million years prior to habitation, adjacent snow melt and rain falls formed flowing waters that eroded the land into a now canyon that is approximately twenty miles long, four hundred feet deep, and 1/4 mile wide (National Park Service, 2015). After many years of other natural geological change and diverting water supplies, this creek later developed into an intermittent stream thus running mostly in spring, and after summer and fall rains, which importantly provided a migration corridor for wildlife species. This stream then developed meandering channels on the canyon floor which enabled numerous shady pools to help hold water and provide containment sources when the stream was dry.

The topography of the canyon is dramatic with the rim elevation at 6,690 ft, the canyon floor 350 ft lower at 6340 ft, and the ruins themselves at about 2/3 of the way up the canyon face (National Park Service, 2015). Geology of the canyon offers differing materials which supports the housing construction. The inner portion of the canyon is comprised of sandstone, and the upper ledges where the dwellings lie are formed of limestone which thus facilitated the deep cutting and excavating of shallow and low rooms. It is believed that this construction was at its peak from about 1100 to 1250 A.D., and it is assumed that during that time about one hundred people called Walnut Canyon home (National Park Service, 2015).

An approximately one mile constructed trail now loops around the central part of the park which allows access to about eight ancient cliff dwellings. This Island Trail runs along the northern slope of the canyon, thus bisected by the old river corridor, and shows dwelling orientations facing south, east and west (Figure 62-63). The trail loop passes by previous homes which are mostly tiny, one room spaces separated by adobe mud brick and stone walls (Figure 64). These rooms are quite amazing in that- as I did when I visited the Canyon in 2005- in the corners of these walls you can still see fingerprints from the wall builders. Directly across the river corridor on the northern slopes of the southern side lie perhaps the most pristine dwellings. They are also built into the limestone cliff, but have small window like openings in walls facing north, east and west. These dwellings and cliff faces have no trail access to probably help keep their undisturbed and authentic status, but their facades are seen quite well from the facing trail.



Walnut Canyon has seen destruction and degradation since the Sinaloa left, and it is through restoration efforts and a protected land status that the park is now somewhat intact. Railroad expansion in the 1880's enabled the most destructive period where many visitors labeled 'pot seekers' brought dynamite and excavated areas, demolished walls, destroyed artifacts, and desecrated graves, thus leading to the protected National Park designation years later. (National Park Service, 2015).

The natural features of the canyon are perhaps the major reason why people flourished here for many centuries. The occurrence and holding capacity of water in a desert area otherwise dry, determined the success of this long running community. This area is still regarded however as a "biological hot spot" due to its many unique natural features, but the features are being negatively impacted (National Park Service, 2015). They included varied topography and elevation which supported a dense forest and dry desert on adjacent canyon sides, and thus, diversity of plant and wildlife species; varied sun and shade patterning supplying stable food, medicine, and material source; and most importantly a level of protection from the elements and hostile visitors (Ibid).

The intermittent stream running along the canyon bed provided wildlife diversity and water supply, but in the early 1900's dams were being constructed to divert the creeks water for public drinking water use, and since the last dam construction date of 1941 the stream has since run dry (Ibid) (Figure 65). This has of course impacted the ecological features and health of the area; the Walnut trees for which the canyon was named are dwindling, and new species are crowding the former open corridor. Riparian restoration efforts are being made, but in a regional area that has limited drinking water resources these efforts are often met with hesitation and disagreement from the city. Flagstaff's priority remains the supply of water for the people and not necessarily the supply for ecological restoration. (National Park Service, 2015).



<http://leonids.us>

Lessons Learned Applicable to Chosen Site:

**Earth bermed and sheltered houses are not new:** Humans have been building in this way since the beginning of civilization.

**Depending on interior use, aspect may not have to be south; utilize what is available:** These dwellings were built into the natural features that were available and logical at the time. The dwellings all have one out-facing wall, but the wall varies from north to west-facing.

**Limited accessibility could be seen as desirable; it adds private space:** In coming times, perhaps, issues of home protection may be more pertinent, and houses constructed with a limited visibility, and access to, may prove popular.

**Flowing water; diverse habitat; soil fertility and supportive climate are essential for a flourishing community:** Civilization flourished here for about 150 years with what was naturally available. A community centered around guiding ecological principles will possibly survive better than ones that are not.



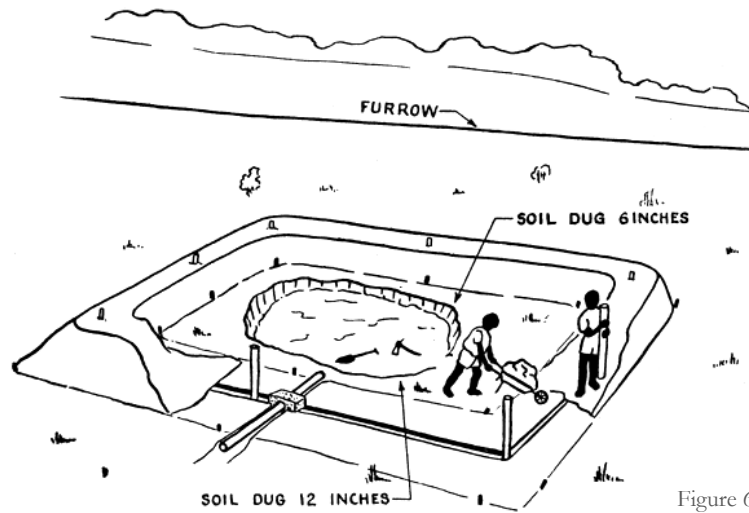


Figure 66  
<http://www.fao.org>



Figure 67

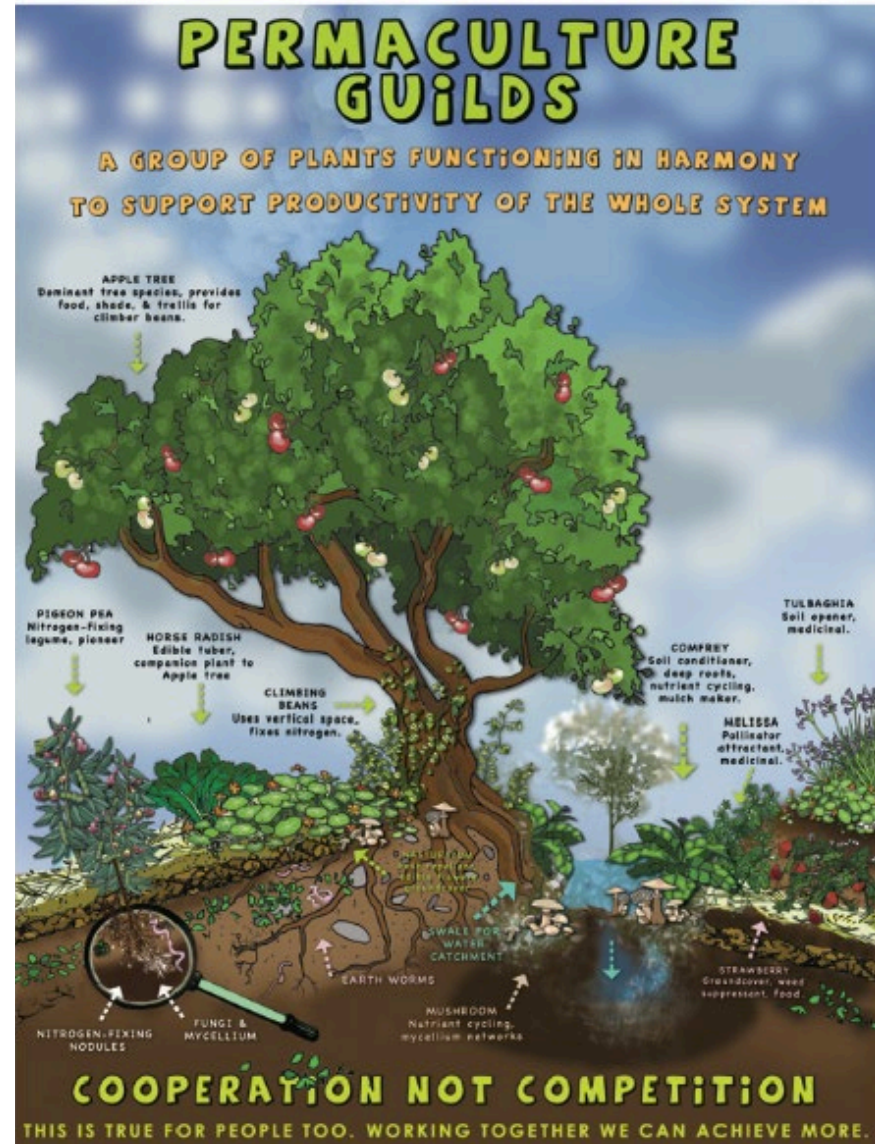


Figure 68  
<http://afristarfoundation.org>



## CHAPTER 4: METHODOLOGY

### Regenerative Landscape Strategies

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A wide variety of tools have been explored in the previous pages. Many of the tools discussed in the Literature Review as well as the Case Studies are utilized in this design of this regenerative community with earth sheltered homes. Other implemented tools have not been generously explored, but they, in large part, are essential elements of implemented strategies.

Certain landscape features and practices will enable the overall regenerative capability of a landscape. Such features and practices, of course, fall under the umbrella of organic farming and gardening. The organic farming and gardening implemented and designed features that enable a regenerative landscape, therefore, are as follows:

- Aquaculture barrage ponds with tilapia harvesting and reuse of nutrient rich habitat waters for crop irrigation (Figure 66)
- Scrap and humanure composting areas, vermiculture (worm cultivation) piles
- Companion planting of crops (Figure 67)
- Mulch covered areas, cover cropping and ground covers for weed control and nutrient cycling
- Silvopasture- growing animals and trees together in the same space, meadows with bee habitat
- Animal husbandry, tall grass grazing, animal brush and forage clearing
- Permaculture guilds and spatial organization (Figure 68)

## True Regeneration Implementations

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Other implemented elements essential to the long terms functioning of a truly regenerative landscape, and which are employed in this community design are as follows:

- Wind, solar, and methane generation (animal waste fed anaerobic methane digester (Figure 69)), wood burning interior heat
- Recycling, reusing, and composting of commercial goods, products and wastes; composting toilets and constructed wetlands (Figure 70)
- Water collection, cisterns; graywater furrows/swales to initiate reuse and filtration
- Habitat protection; restorations and biodiversity support (Figure 71)
- Food security- edible landscapes (Figure 72), perennial grains and crops, rice paddys, greenhouses (Figure 73), rootcellars and seed banks
- Educational space for community involvement and outreach education (Figure 74)
- Independent economic stability- CSA to generate income as well as educational demonstrations, seasonal product fairs and festivals



<http://googleimages.com>



Figure 69

<http://jordandairyfarms.com>



Figure 70

<http://googleimages.com>





Figure 71



Figure 74  
<http://heifer.org>



Figure 72



Figure 73  
<http://pinterest.com>





## Earth Sheltered Architecture Strategies

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Implemented elements of previously discussed earth sheltered architecture are:

- Passive solar when possible, direct gain approach
- Balance of cut and fill, earth insulating capabilities when slopes allow
- Concrete shell and wood facades, soil and standing seam metal roof to cultivate crops and collect rain water
- Glass walls and clerestory openable windows
- Earthships 'Little Bricks' recycled glass in interior walls (Figure 75)
- Landscape and native wildlife habitat integration
- Earth toned and traditional housing colors
- Burstabaer Icelandic turfhouse, pit house and New England style hybrid (Figure 76-77)



<http://earthships.com>



<http://pinterest.com>



Figure 76  
<http://www.jodyeddy.com>



Figure 75  
<http://www.earthships.com>



Figure 77  
<http://www.bcarc.com>



## Regenerative Community Strategies

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As mentioned, most earth sheltered houses are built as single units which are not part of a community setting. However, an efficient such community would probably follow the same principles other communities share; most notably the typologies that cluster housing developments offer. These community strategies in addition to the aforementioned regenerative and earth sheltered elements are listed below:

- On site amenities for residents such as stores, a wellness center, and recreational activities
- Landscape preservation, building on a limited area close to existing infrastructure and utilities
- Inner pedestrian and emergency circulation, main vehicular outer
- Community feel with shared spaces/ amenity/ and equipment borrow and storage
- On the interior, houses share a garage wall, water and electric pipes, and utility and storage facilities
- On the exterior, houses share roof gardens, water collection, solar generation, crop gardens, play spaces, cooking and gathering spaces, wash and shower areas, greywater infiltration areas, composting areas, wood storage, and mail and trash areas

A Community that was partially referenced for this list of strategies was Pioneer Valley Cohousing on Pulpit Hill in North Amherst, Massachusetts.

This is a dense cluster development community with thirty single family and duplex homes built on one acre of a moderately steep hillside (Figure 78). The vehicular circulation is kept to the outsides aside from emergency access, and the residents and visitors park their cars at parking lots on the periphery of the development (Figure 79). The residents share a community building, storage spaces, outdoor equipment, and a very large productive garden. Upon my visit to this community in 2013, a resident told me of the many joys surrounding living in this cohousing; many residents have lived here for twenty years, and there is a waiting list to live in the community.



Some negatives pertained mostly to the elderly residents and they were: winter access to the homes is a challenge, and this resident suggested one should only build on a hillside if direct home access is provided for, and noted many residents wished they had a garage.



Figure 78

<http://www.cohousing.com>

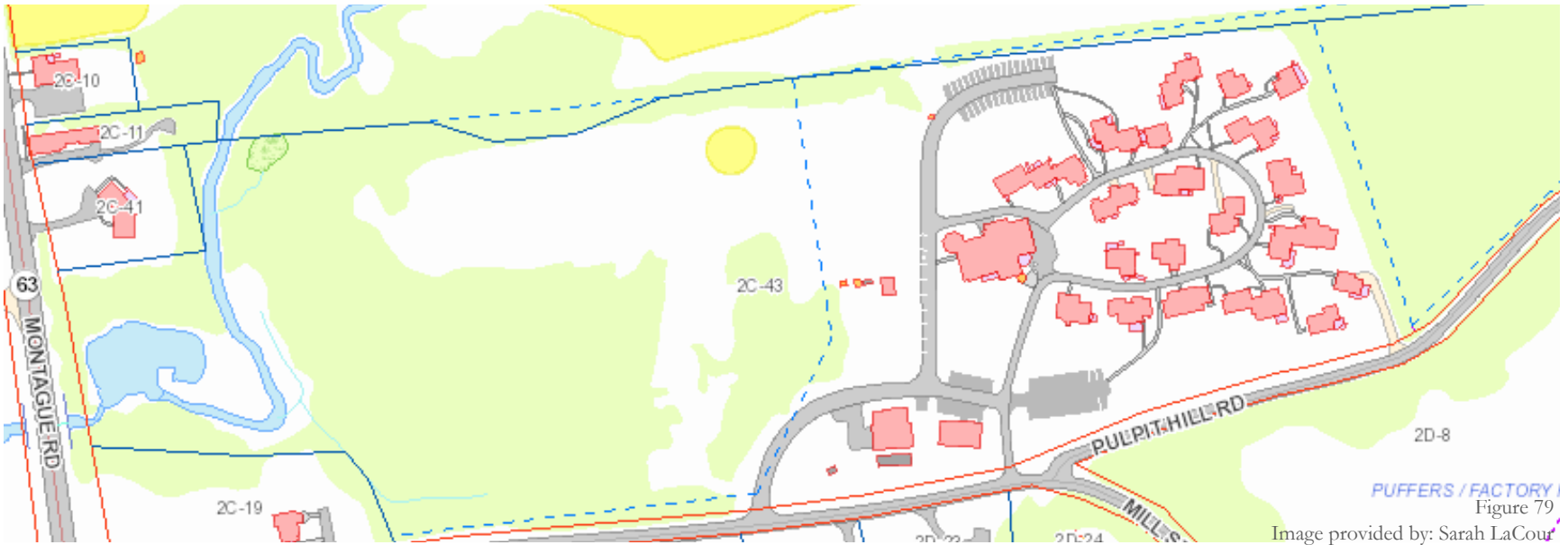


Figure 79

Image provided by: Sarah LaCour







## CHAPTER 5: SITE OVERVIEW AND DESIGN IMPLEMENTATION

### Locality Justification

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For a regenerative community with earth sheltered houses to work to its fullest benefit natural features such as topography; existing native vegetation including established trees, shrubs and grasses; ample water supply; stable and well draining soils and southern facing slopes are ideal. An economic need and market for this minimally disruptive built, or retrofitted structure, and some existing cleared land for crop production are also desirable.

While there are many places throughout the world, and in the United States in particular, that suit this broad criteria, as of this date a regenerative earth sheltered housing community has not yet been built in New England. In Massachusetts in particular, again there appear to be a few earth sheltered houses, however, local information, published work, and public awareness on their attributes remains scarce. The reason for the scarcity and rarity of these communities and housing styles in New England and Massachusetts remains unknown, it seems likely however, that a market desirability of these houses and communities has just not been evaluated, and that the public is unaware of these alternatives. It does not appear the rarity is due to the impossibility of earth sheltered construction in this region or state, and it is the intent of this project to determine Massachusetts feasibility.



Eventhough other New England states also support desirable traits, for effective community integration to the existing cultural landscape one designer must have a familiarity and connection to the local landscape. My connection to the local land and culture remains strong as I was born and raised in central Massachusetts. While researching potential sites and taking all things into consideration, including economic and sustainable drivers, a 60 acre parcel of Wachusett Ski Mountain in Princeton became the obvious and most feasible choice.

## Wachusett Mountain

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Wachusett Mountain, located primarily in the small central Massachusetts towns of Princeton and Westminster, is the highest mountain in the state east of the Connecticut River, and it is the largest ‘monadnock’ (mountain that stands alone) east of the Berkshires (Wachusett Mountain, 2013). Wachusett Mountain Ski Area, which is part of the Wachusett Mountain State Reservation, is currently operating under a one hundred year lease from the state of Massachusetts; being granted in 1969, the lease is set to expire in 2055 (Ibid). Run by the Crowley family, the Wachusett Mountain Ski Reservation operates in conjunction with the MA Department of Conservation and Recreation (DCR). The lease area mostly resides within Princeton town boundaries and totals about 450 acres, of which about 100 are used for winter skiing and snowboarding. Atop its peaks are some portions of the only remaining old growth forest in central Massachusetts, and on a clear day the Boston sky line is visible from the summit. The reservation currently supports active summer hiking and biking, winter skiing, and various indoor and outdoor events; year round it attracts around 600,000 visitors, thus providing economic support to small Massachusetts towns and local businesses. If this support was to decrease, the economic vitality of these towns might be in question.

To operate the snow making process about one hundred million gallons of water, leased from Fitchburg, are used each season (Wachusett Mountain, 2013). With climate change water may become in scarce supply in many areas, and leasing of it for recreational purposes may cease. Also, these climatic effects are set to dramatically alter the local landscape, and reliably cold temperatures and snowfall may not be guaranteed, thus causing winter recreation to become an unstable economic generator.



## Princeton, Massachusetts

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Princeton is a rural, agrarian, small New England town incorporated in 1759 (Town of Princeton, 2015). Located in the north central part of the state (Figure 80) it is part of the Wachusett Regional School District along with the four other neighboring towns of Holden, Paxton, Rutland, and Sterling. Princeton itself has the highest median income as compared to the other central Massachusetts towns (Figure 81) but is suffering from population loss due in part to a lack of available buildable land and affordable housing. Compared to the top three district towns, Amherst, and Boston: Princeton's median income is \$120,607; Paxton is \$106,375; Sterling is \$98,872; Boston is \$53,601 and Amherst is \$53,191 (The latter two being considerably lower possibly due to the large number of college students registered in Boston and Amherst) (U.S. Census 2015). Demographics of the town indicate a predominant white ethnicity and the median age is 43.8 (Ibid).

The 2013 population was 3,424 people, and according to Dr. Henry Renski and the Umass Donahue Institute Population Estimates Program, this decline will continue as Princeton populations are projected to decline by 11% to the year 2030 (Renski 2014, MA Population Projections). This high average income could support a market for this alternative housing and community style which, as explained in preceding chapters, compared to traditional housing requires more custom details and construction elements, thus raising construction and mortgage costs. The majority of Princeton is state classified as a culturally significant landscape, due in part to many historic homes and farmlands. New and available buildable land in Princeton is low due to steep topography, the large area of land under protection by the DCR, and still active farmland. Population loss could be mitigated if available land increased outside of protected and farm lands, and on sites with high gradients. Earth sheltered housing construction would allow these topographically significant sites to be viable.

The declining population is also due to the lack of affordable and senior housing options. Zoning of the town is primarily two acre lots with single family, residential/ agricultural use (which occupies 85% of the buildable land). Variations are allowed by special permit









Figure 80  
Data Source: Mass GIS

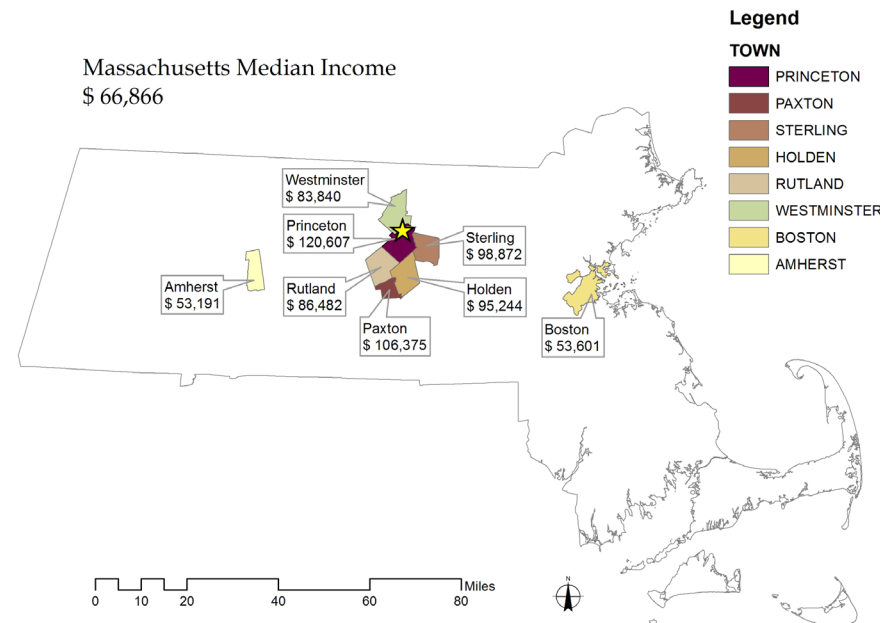


Figure 81  
Data Source: U.S. Census, American FactFinder



Town Common

or board approval, but as the 2007 town master plan discusses, the current zoning is ambiguous and the town planners recommend amending the zoning to add cluster zoning with land conservation restrictions to the town regulations (Master Plan 2007, 19). A lack of affordable and smaller housing options also is evidenced by the high median house values and the average number of rooms in each house. Of the 1,234 total housing units in the town, 25% were built before 1939; the median value is \$352,900, and the average number of rooms is 7.2 (U.S. Census 2015). This indicates that on average the houses are large and out of economic reach for a wide variety of perspective residents.

With all factors considered, and potential for climatic changes to dramatically alter both the physical and economic landscape of Princeton, it seems a discussion of how to best and pro-actively respond to their projected housing, population, and land use changes is extremely pertinent. Shared cluster development housing could help increase revenue in the town, and this design proposes such development.



Current food and office business





Typical historic housing typologies with mature maples and oaks and stone walls





Contemporary adaptations, unique and large homes and typical hillside typology



## Mountain Analysis and Assessment

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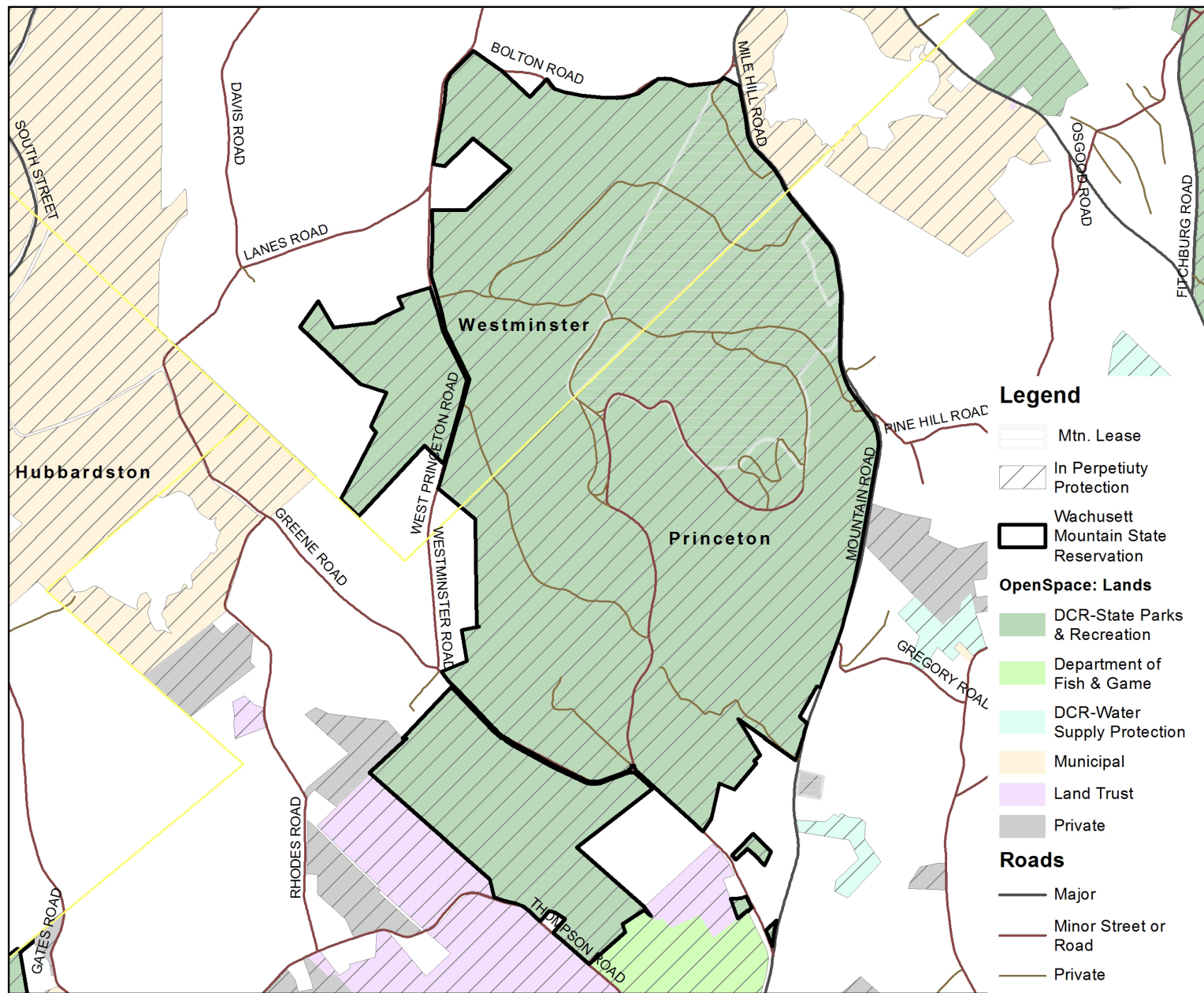
Many natural elements and factors are important to consider when deciding on the best location that supports the lowest environmental impact of a proposed housing development. The mapping data found in the Massachusetts Office of Geographic Information Systems (Mass GIS) provides this data, and it was used to compile the maps and ecological assessments shown in the following pages.

**Property Ownership-** Based on this map it is clear that the majority of Wachusett Mountain is under in perpetuity protection status by the Massachusetts Department of Conservation and Recreation. A smaller area to the northeast is not under this same protected status and is suitable for possible development. This area is the current leased area of Wachusett Ski Mountain which is set to expire in 2063 (Figure 82).

**Regional Trail and Prime Forest-** Most of Wachusett Mountain is under Prime 3 Forest status. There also exist smaller portions of Prime 1 and 2, Local Importance, and limited Local Wet Forest designations. Prime Forest is a state designation based on the value of the primarily White Pine and Red Oak timber productivity of the forest (Mass GIS 2015). The majority of the area under the Ski Mountain lease is under no forest designations as the land has partially been cleared for ski trails. The Midstate Trail also bisects the mountain (Figure 83).

**Scenic Landscape and Habitats-** The eastern side of the mountain is valued as a Distinctive Landscape, and the western side is largely designated as a Noteworthy Landscape. These scenic designations are part of the Scenic Landscape Inventory determined by state offices. A Distinctive Landscape is one with the highest visual quality and is designated based on its openness, lack of contemporary development, historical and agricultural features, mature vegetation, and low population. A Noteworthy Landscape is lesser degrees of all that qualifies as Distinctive, and landscapes without these designations are classified as “common” (Mass GIS 2015). Portions of Wachusett Mountain are also under NHESP (National Heritage and Endangered Species Program) Priority Habitats of Rare Species designations. This identifies areas of species’ habitats that are to be ecologically managed, and in cases of wildlife, often left undisturbed. Species found here are an open land



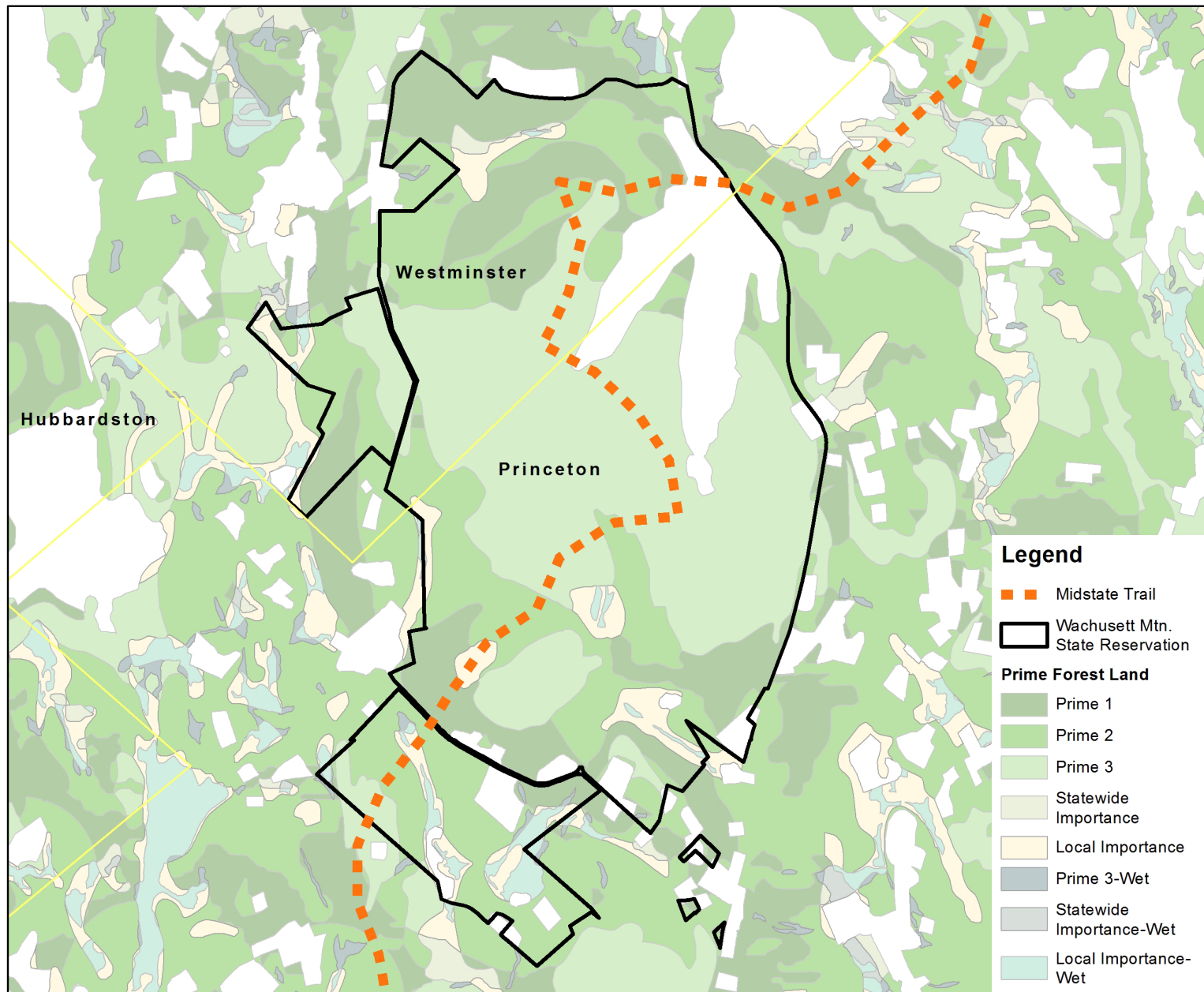


Property Ownership

0 1,250 2,500 5,000 7,500 10,000 Feet



Figure 82



Regional Trail and Prime Forest

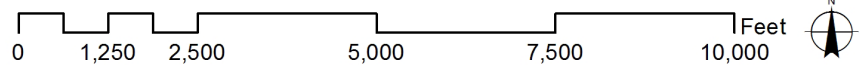
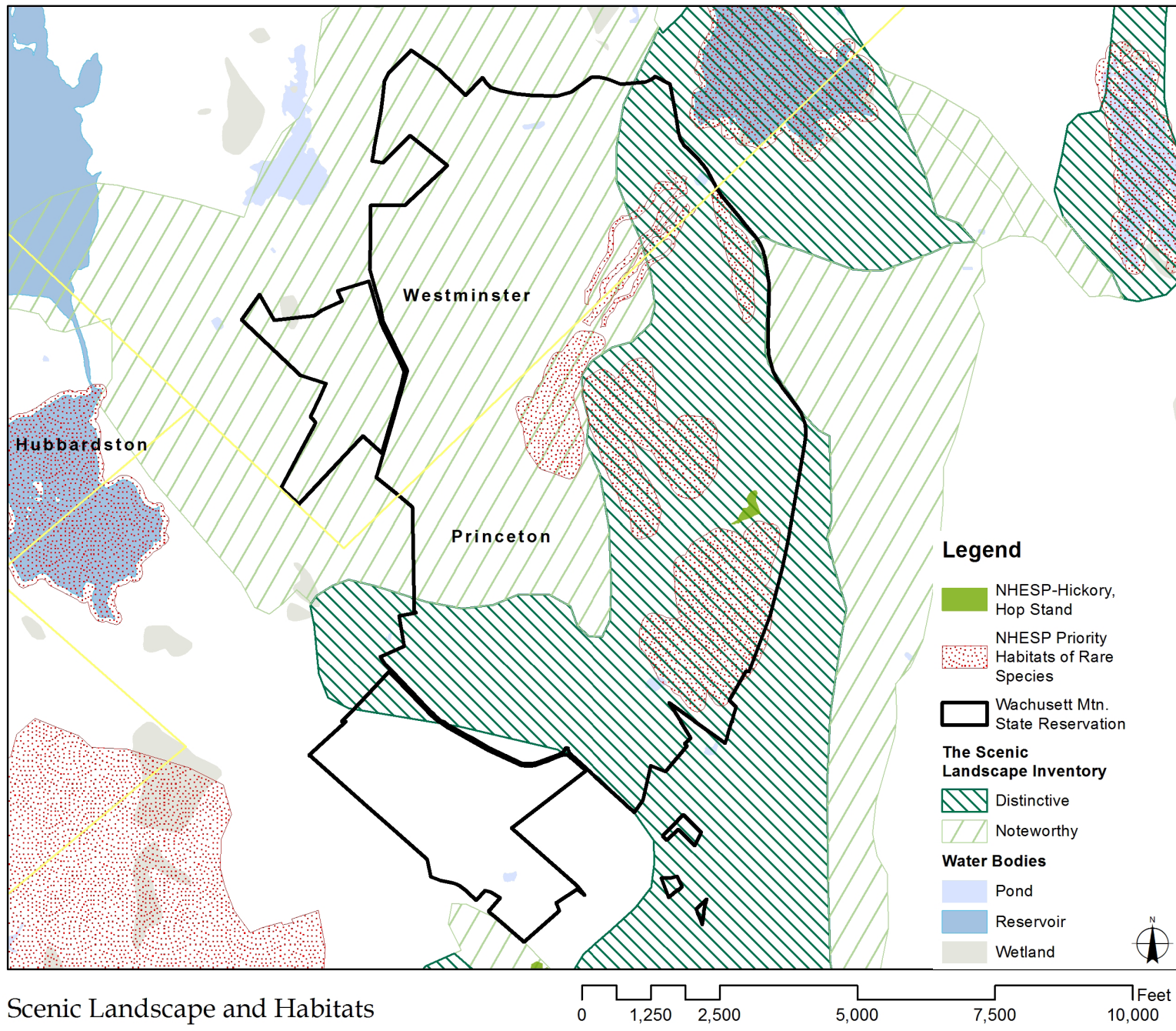
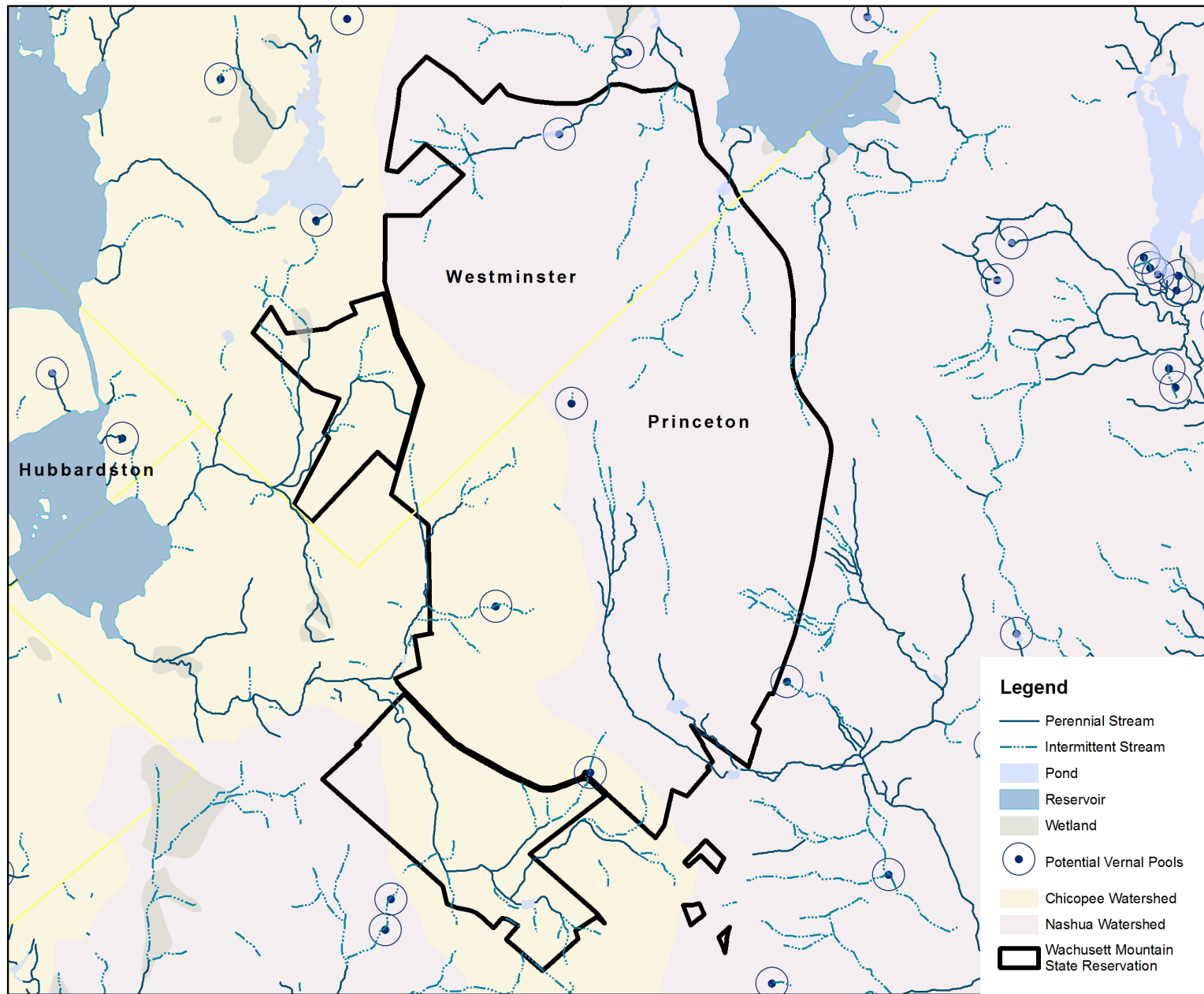


Figure 83







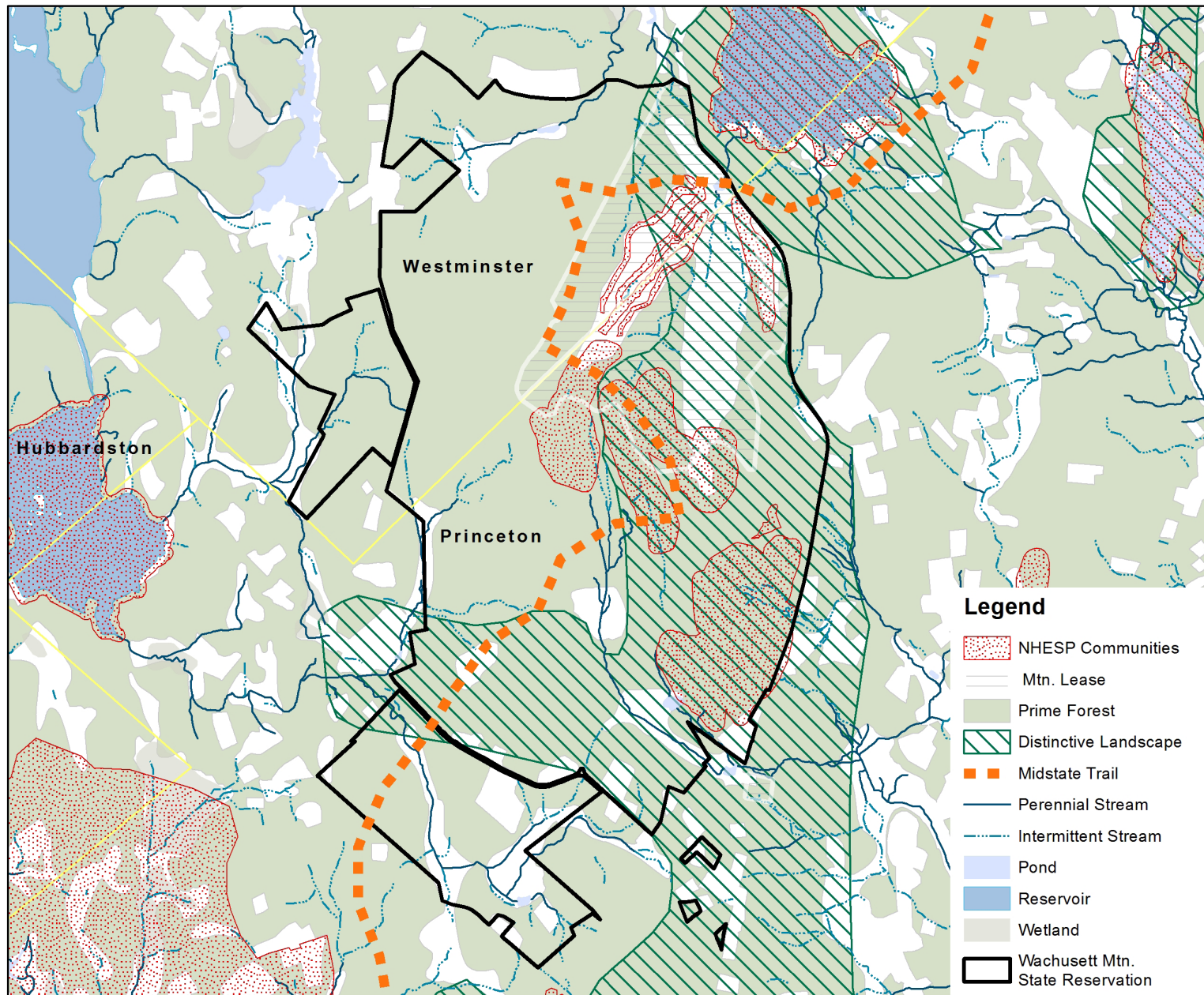


Hydrology

0 1,250 2,500 5,000 7,500 10,000 Feet



Figure 85



Conservation Composite

0 1,250 2,500 5,000 7,500 10,000 Feet



Figure 86

species of sedge which favors full sun and open meadows, and would mostly decline under a thick tree canopy (Mass GIS 2015) (Figure 84).

**Hydrology-** The elevation peaks separate the mountain into the Chicopee to the south and Nashua Watershed to the east. (Interestingly, the mountain being a part of the Nashua River Watershed is the reason why Lidar data was available, which was then used to generate one foot contours necessary for this design proposal. Lidar data is expensive and often only scanned in areas prone to flooding damage.) There are also perennial and intermittent streams that run down the mountain slopes, four potential vernal pools, and a mapped pond at the northern boundary near the Princeton line. This pond is found at the base lodge of the ski mountain lease (Figure 85).

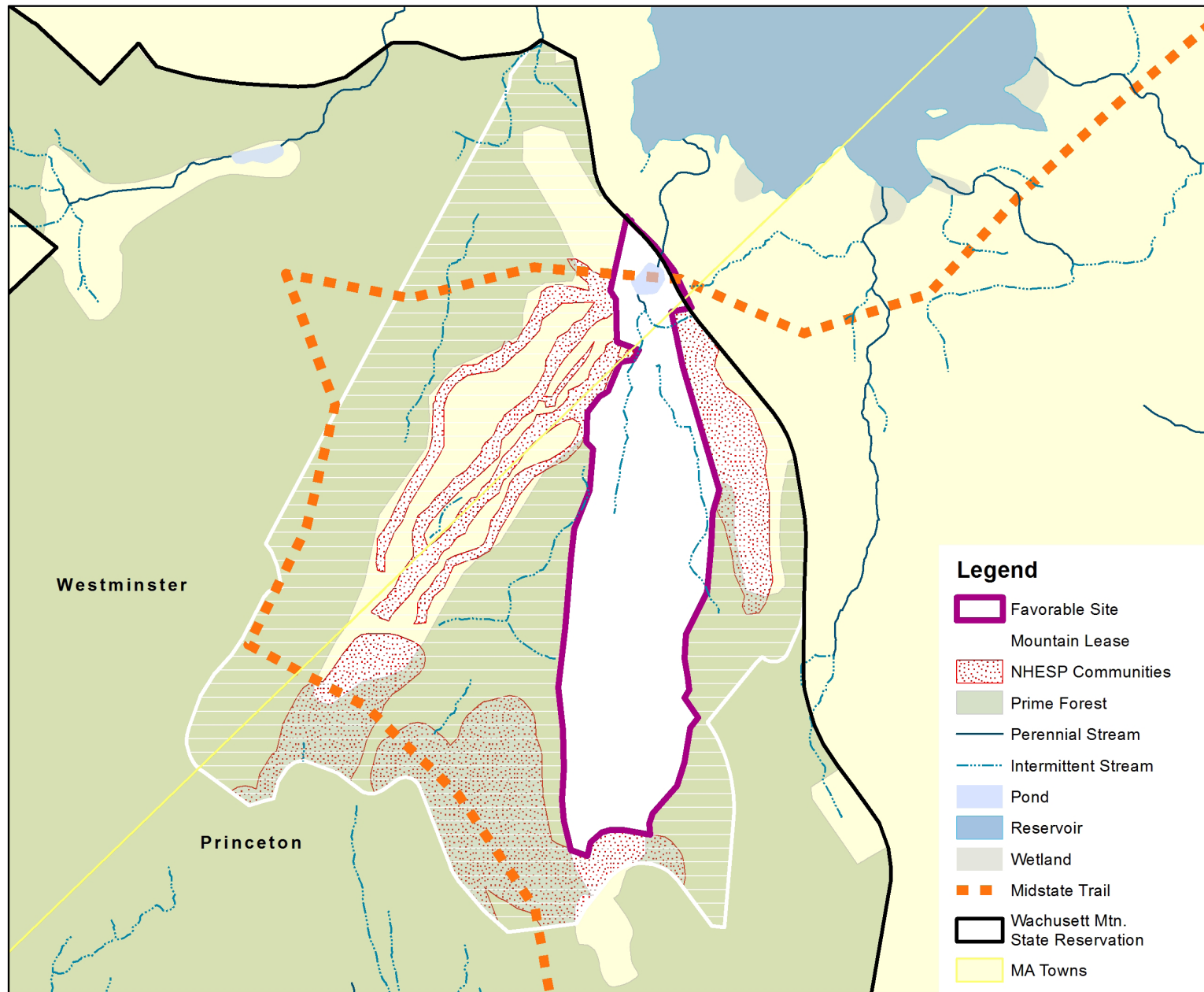
**Conservation Composite-** Based on the four preceding maps, a composite map of a suitable site to build this proposed community was made. This map overlays the important features and identifies key areas. The mountain lease area is under NHESP Communities, Prime Forest, and Scenic Landscape designations. It also has intermittent streams and the Midstate Trail running through the area. There is also an oblong oval shaped area within this leased area that is devoid of Prime Forest and NHESP Communities (Figure 86).

**Favorable Site Composite-** The composite map identified the area that makes up the favorable site boundary. This area has intermittent streams and a pond but no other ecological constraints. According to this level of assessment, the favorable site is the most suitable for building and the initial site boundary of this design proposal. This map also gives the first challenges and limitations of north eastern slopes and non existing main road utility access (Figure 87).

**Soils-** The mountain is a part of the geological Gondwanan terrane (Mass GIS 2015) and the favorable site largely supports Peru Marlow, Berkshire Marlow, and Tunbridge Lyman Berkshire stony and well drained soils. These soils support regenerative landscape features and earth sheltered housing construction (Figure 88).

**Slope-** The mountain low point is 920' and the high point is 2006' which indicates a change of 1086'. The favorable site has average slopes of 25-35% which is suitable for the design proposal, a low point of 1058', high point of 1920' and a total of 862' grade change (Figure 89).





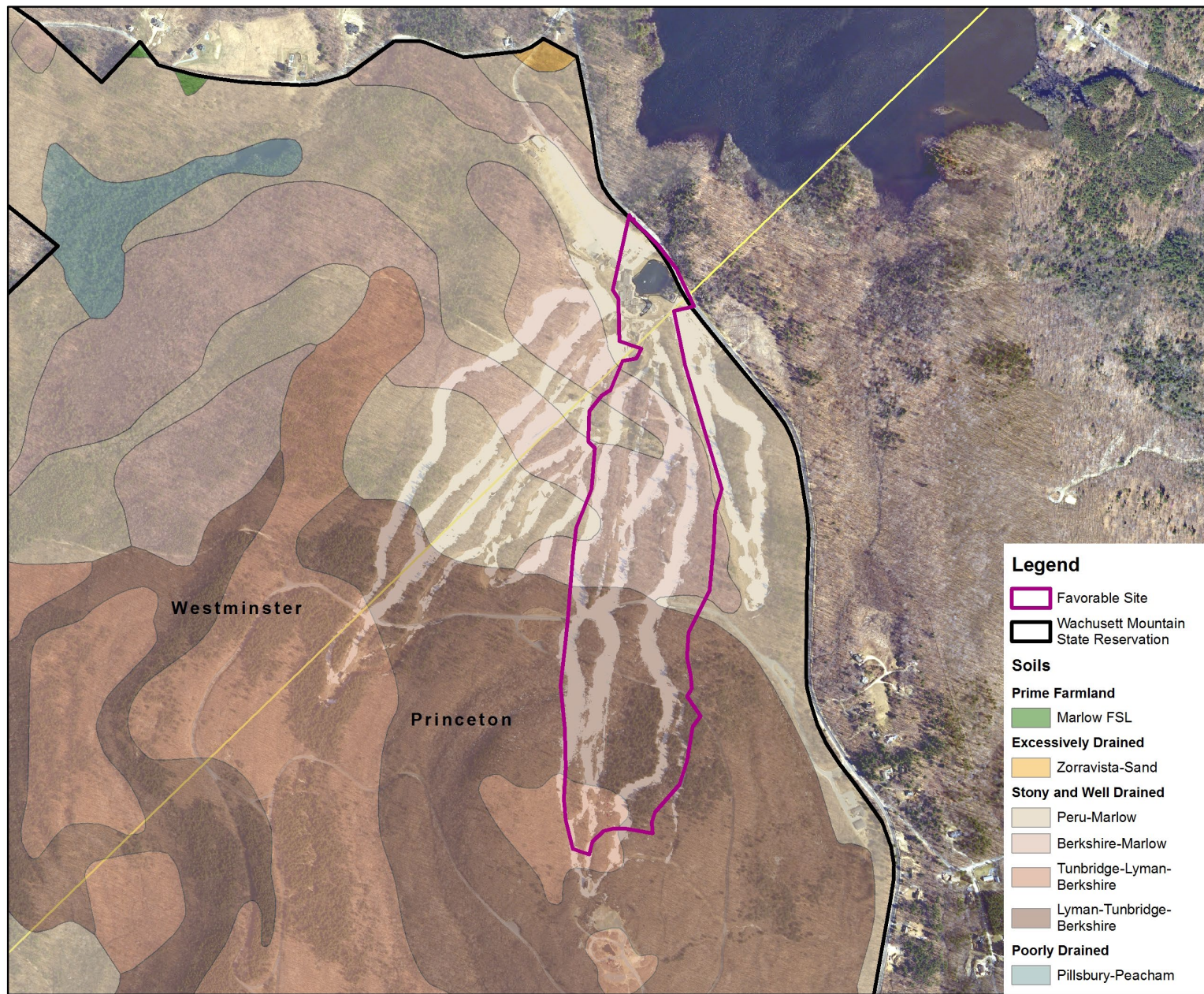
Favorable Site Composite

0 550 1,100 2,200 3,300 4,400 Feet



Figure 87





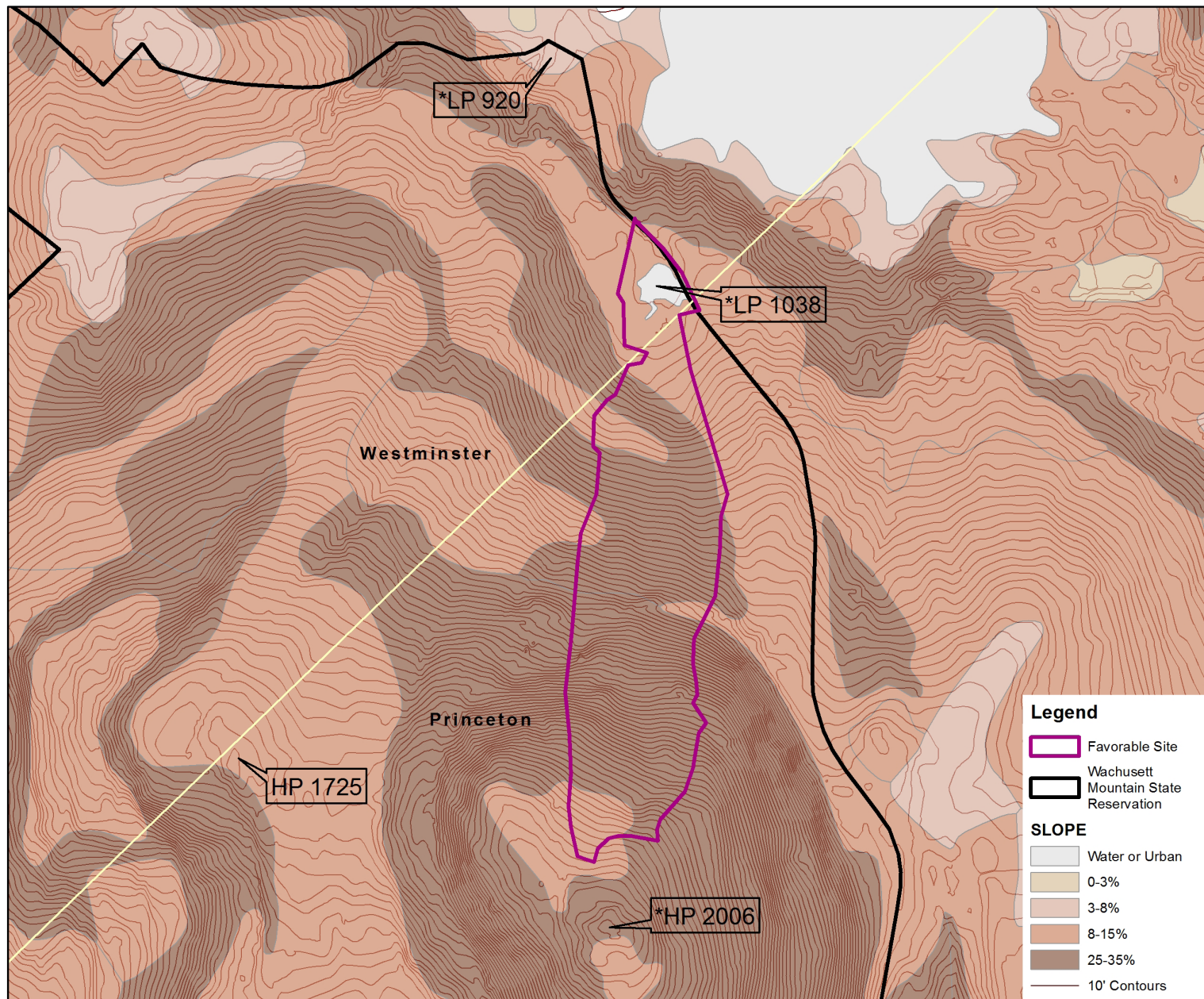
Soils

0 550 1,100 2,200 3,300 4,400 Feet



Figure 88





Slope Analysis

0 550 1,100 2,200 3,300 4,400 Feet



Figure 89



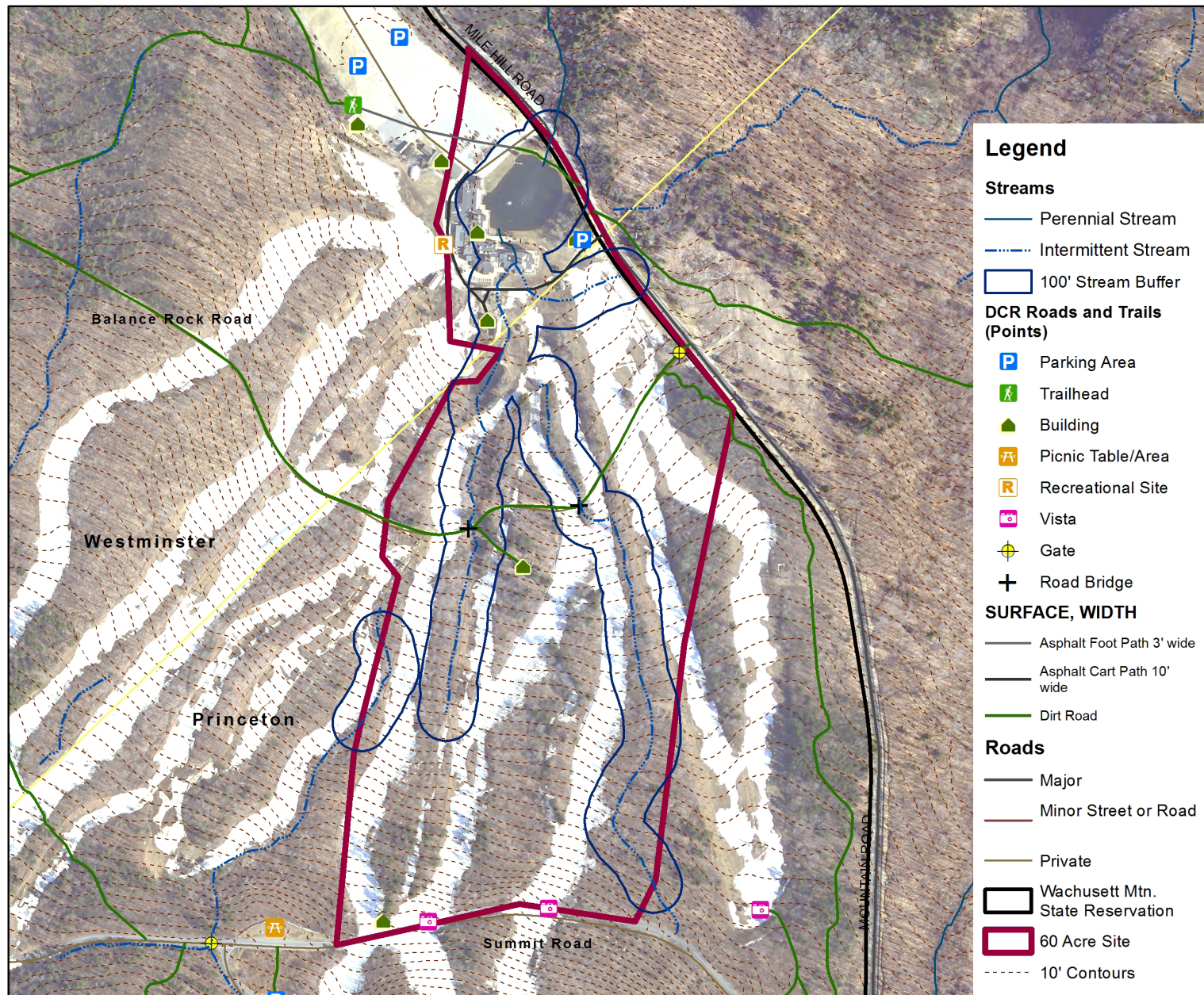
## Site Challenges and Limitations

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Based on the previous analysis, there are challenges for creating a regenerative community with earth sheltered houses on this site.

- **Aspect:** As mentioned in previous pages the ideal aspect for passive solar gain is south. This site, being a ski mountain, has an aspect of northeast.
- **Existing Tree Habitat:** Aside from the groomed ski trails and open areas, a remainder of the site has an existing tree canopy and diverse wildlife habitat. Building in these areas would degrade this habitat and not complete the goal of creating a regenerative community.
- **Hydrology:** Four intermittent streams exist in the favorable site. Standard wetland buffers of 100' limit development areas and the more ecological 200' wetland buffers are not feasible within the site boundary.
- **Slopes:** The 25-35% slopes which support earth sheltered construction exist in the southern part of the site- far from existing buildings and infrastructure. Providing access to each cluster home and garage would require major grading cuts and not fulfill basic sustainability.
- **Existing Roads:** The favorable site is far from existing main roads, and this would require new, longer roads and driveways to be built.

These challenges pose a difficulty in designing a regenerative community. Taking all limitations into consideration, and still trying to achieve the goal and provide a use for a ski mountain that could cease to operate, adjustments to the design site have to be made and are as follows: increase the design site to include the sedge habitat and develop the main community on the 8-15% slopes near existing roads. As mentioned, this sedge species is growing on the sunny, mown ski trails, and if unaltered succession occurs habitat will decline. Therefore developing in this area, and allowing native deciduous plant regeneration with an open meadow understory will help to preserve this habitat (Figure 90).



60 Acre Design Site

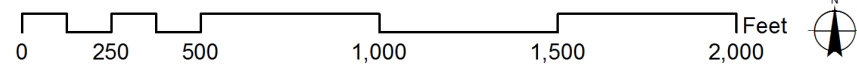


Figure 90

## Approach

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As the challenges dictate a new site area and design alterations, the proposed community could still work on this site. It is possible to partner with the existing ecosystem and make this regenerative community work.

### **Housing Design Alterations:**

- The eastern aspect of the houses will not allow maximum passive solar gain. Aspect of the houses should follow natural topography and have windows on the east, south, and west and allow solar generation, water collection, and rooftop crop harvesting.
- 8-15% slopes will require a case by case design of the houses. The original goal of completely earth sheltered designs will not entirely work in this area as it is unsustainable to not balance cut and fill grading. Homes will continue to be a combination of Pit Houses, Burstabaer Icelandic Turf Houses, and traditional New England styles and will be mostly situated near existing roads and infrastructure.

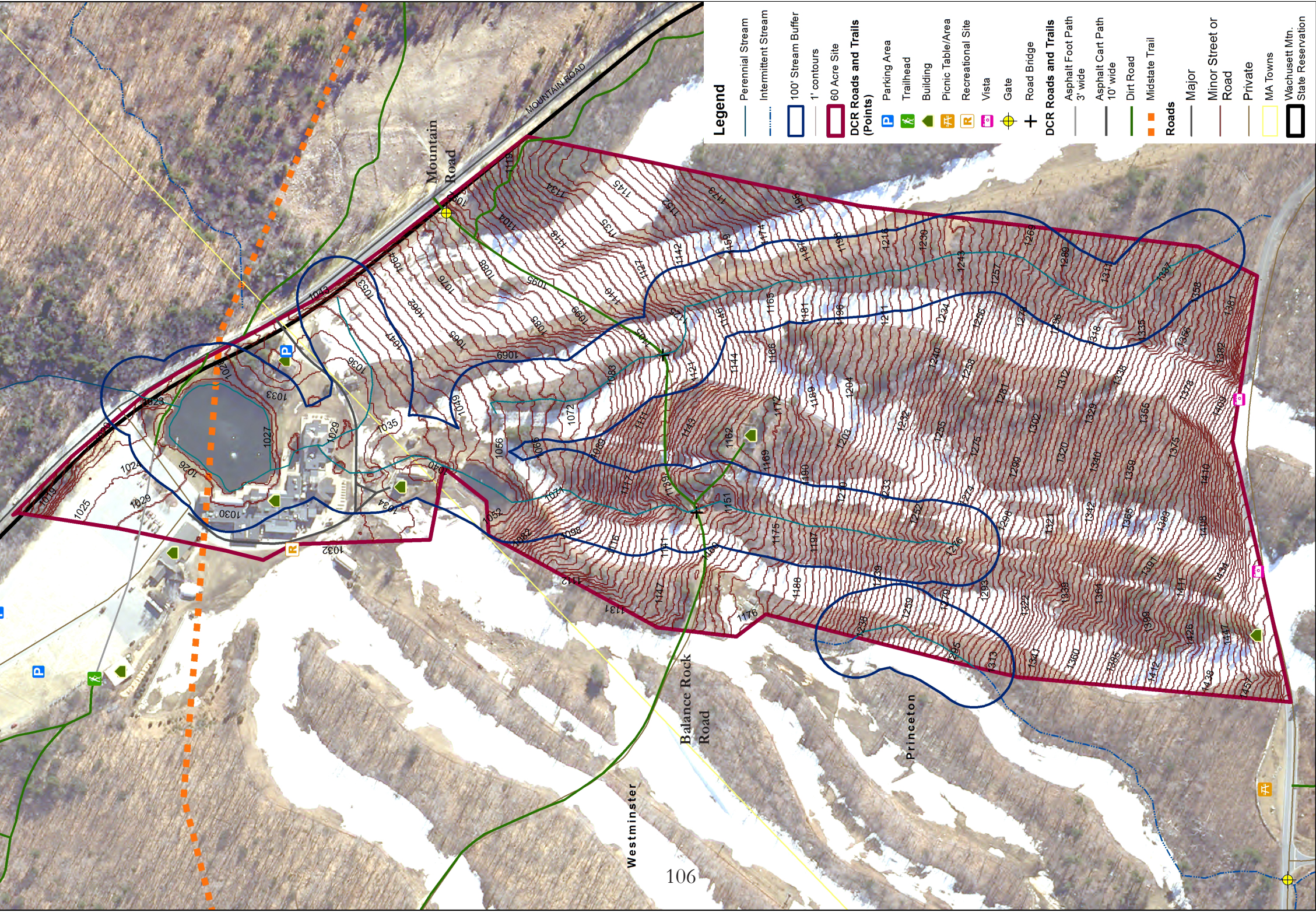
### **Community Alterations:**

- 2 community styles will be designed, one with a neighborly clustered arrangement and the other a more isolated individual development. These individual housing communities will be a part of the larger community.

### **Landscape:**

- To complete the regenerative goals as much growing space as possible should be provided while not degrading existing natural habitat.
- The larger community will be situated to preserve as much existing land and habitats as possible.





60 Acre Design Site

Figure 91



Based on further GIS analysis, this new design site in the zoomed in scale has an increased development area and also supports wind power and crop plantings.

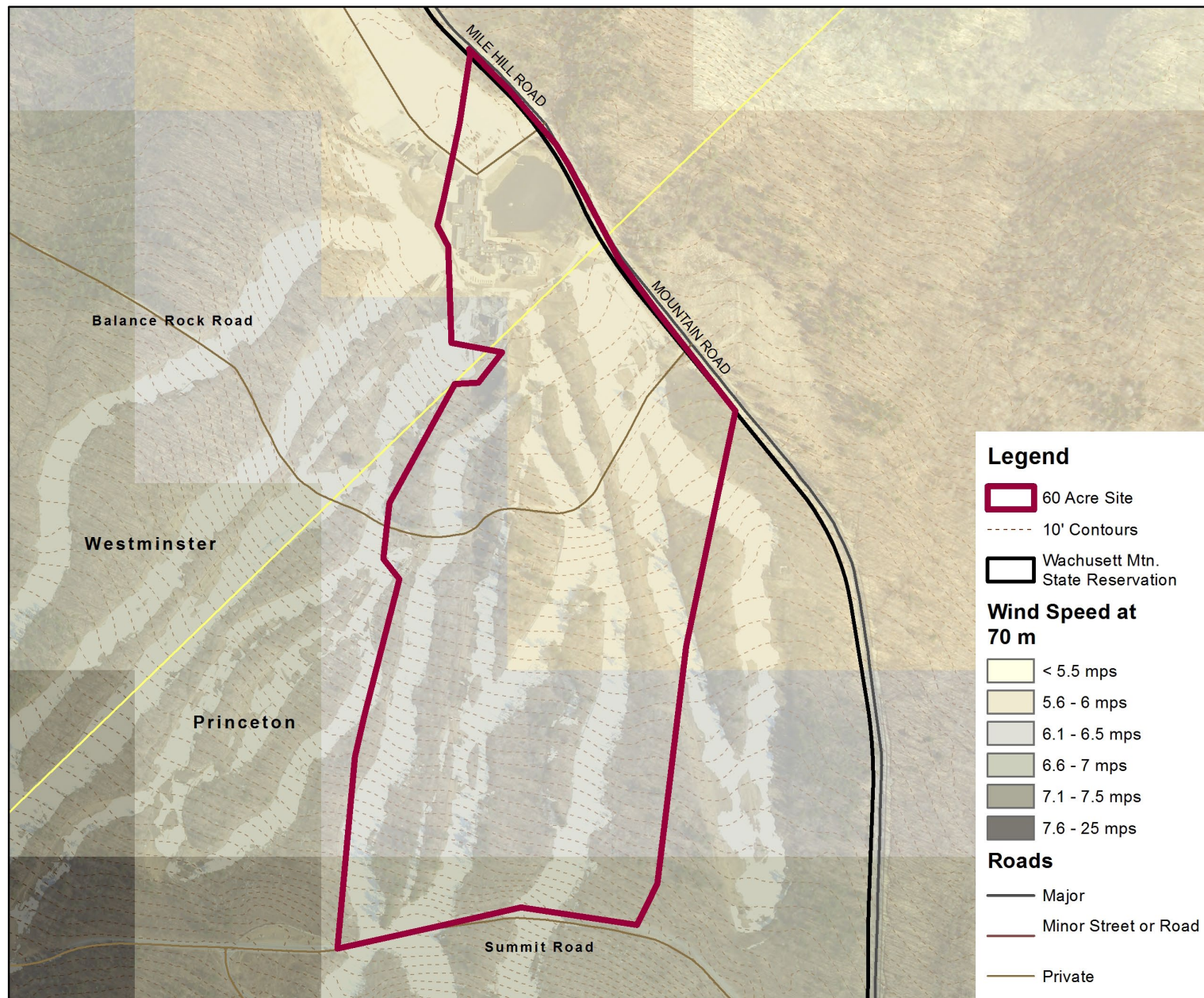
**60 Acre Design Site-** When seen at the large scale this map also shows the one foot contours that were generated using the mentioned Lidar data. The 100' stream buffers still seriously limit housing sites and crop field placements, but the increased area to the right adds potential development areas. This increased area is also parallel to the existing main Mountain Road (limiting new road constructions and initial infrastructures) and bisected by the existing unpaved Balance Rock Road. This unpaved road will be the main branching entry road to the communities (Figure 91).

**Wind speed at 70 Meters-** According to Rob Beckers at Canadian Wind Firm Solacity in order to have effective wind power generation, annual wind speeds need to be at least six meters per second at elevations of eighty meters ( 262') (Solacity 2015). Average install heights of turbines are at around 200', and based on Mass GIS data the southern or topographically top part of the site favors this installation. Generally, sunny days are not very windy and cloudy days are very windy so more generation is achieved in the winter than the summer months, and solar and wind installations and generations compliment each other nicely (Ibid) (Figure 92).

**Hillshade July, 6 am-** Generating topography with the one foot contours shows that the main eastern community and the base of the mountain receive sunlight at 6 am in the summer months, and the western part of the site is still in shade (to about 7 am) (Figure 93).

**Hillshade July, 7 pm-** The eastern part and the base of the site remain in sunlight till 7 pm in the summer months, and the western part receives shade at about 6 pm (Figure 94).

Other generated hillshades show that in February the eastern side and base receive sunlight at around 9 am and are dark at around 4:30 pm.



Wind Speed at 70 Meters ( 230')

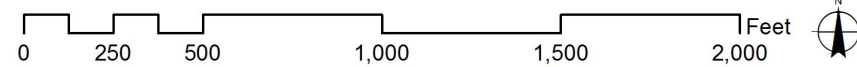
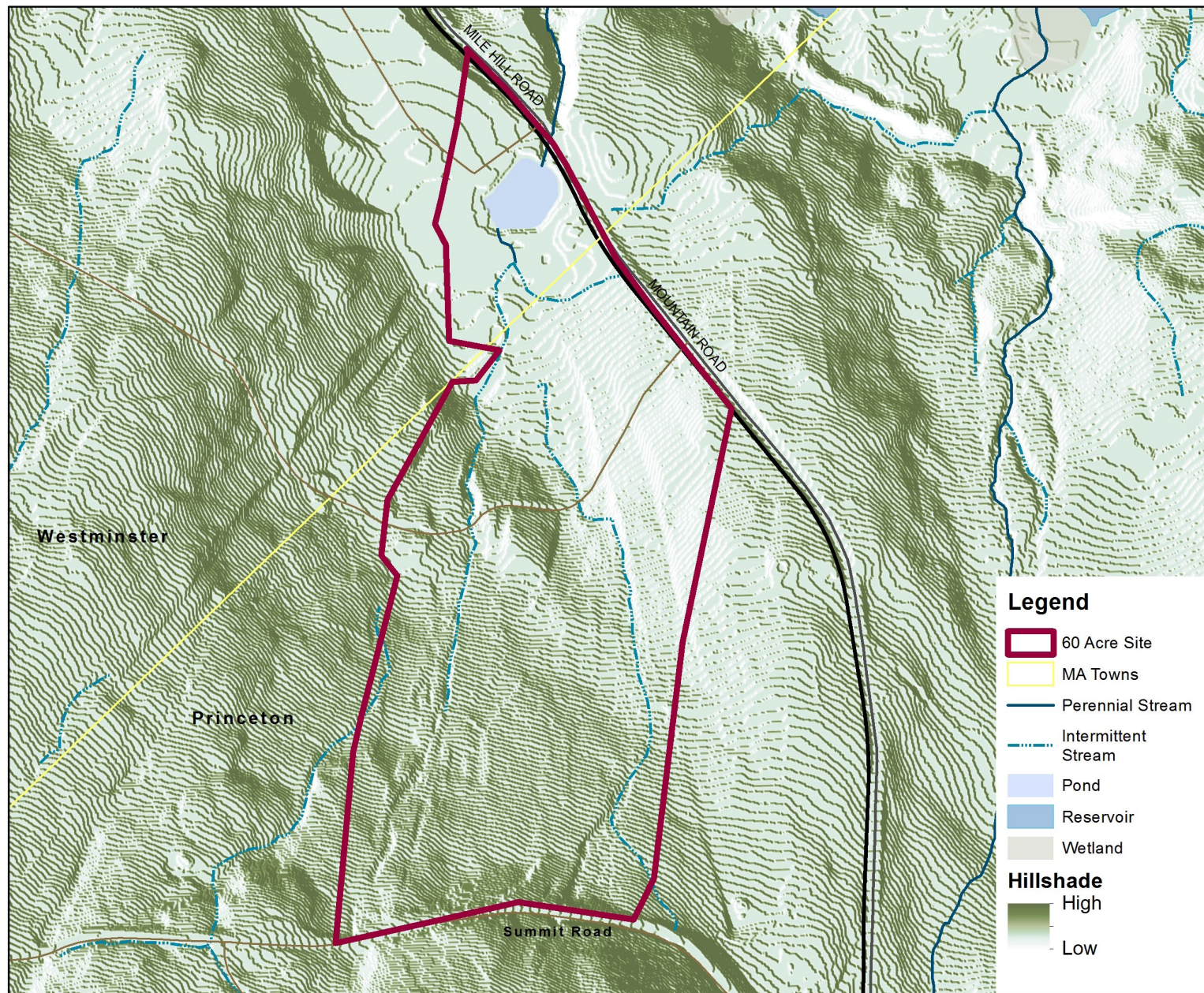


Figure 92





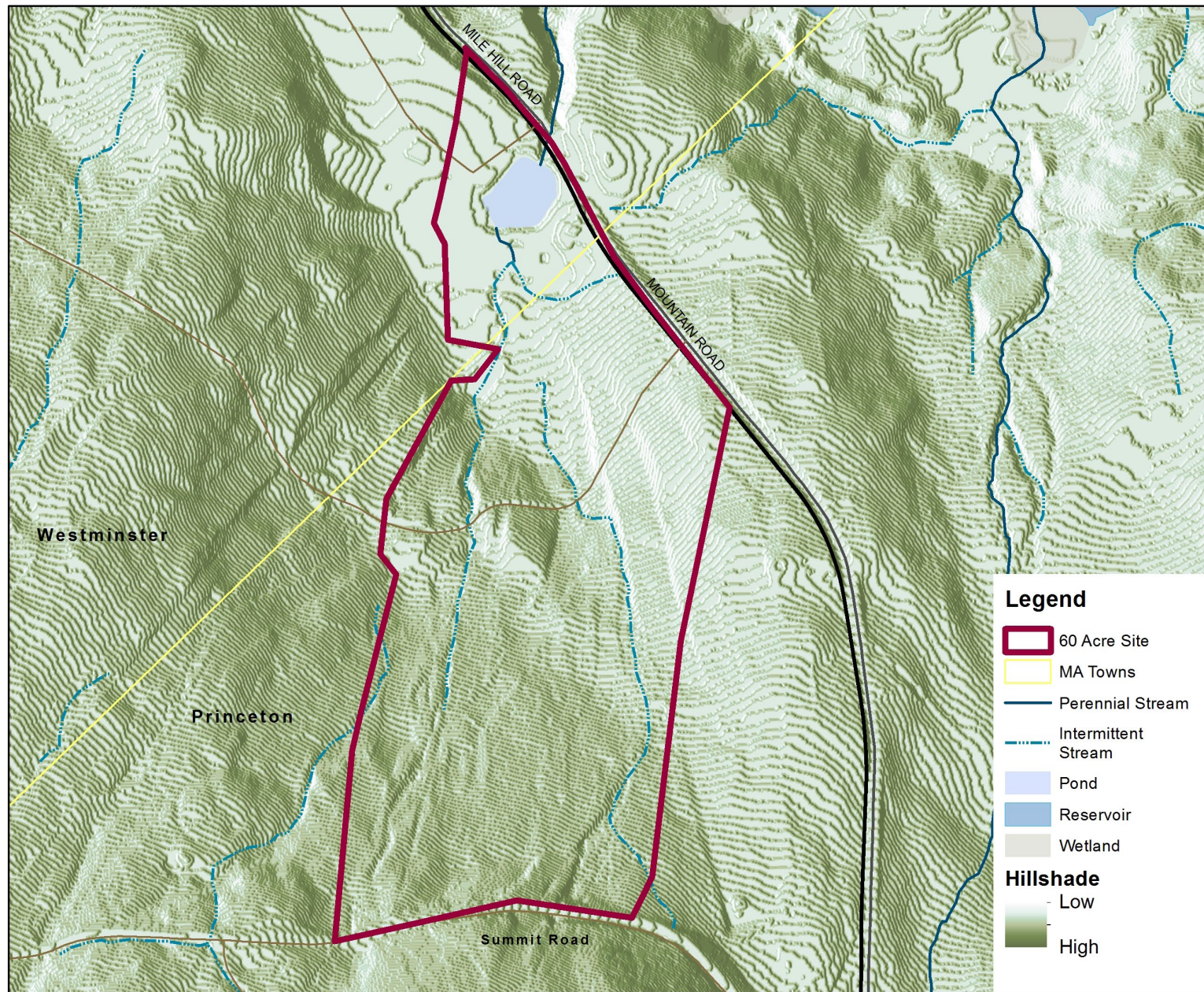
Hillshade- July, 6am

0 250 500 1,000 1,500 2,000 Feet



Figure 93





Hillshade- July, 7pm

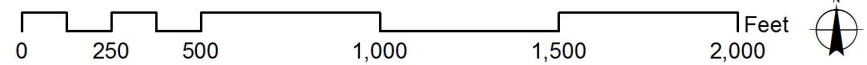


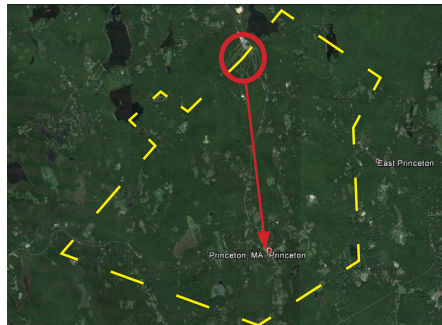
Figure 94



## Design Site Photo Tour

The proposed design site is approximately 4 miles from the town center. This would take a person walking the average speed of 3.1 miles in one hour, about an hour and a half to walk.

Many existing features on this site offer interest and design potentials.



Chair lifts that extend up to the mountain summit.







Wide trails near the base lodge that will become Community East.  
Photo: [http:// wachusett.com](http://wachusett.com)



Base lodge and pond.

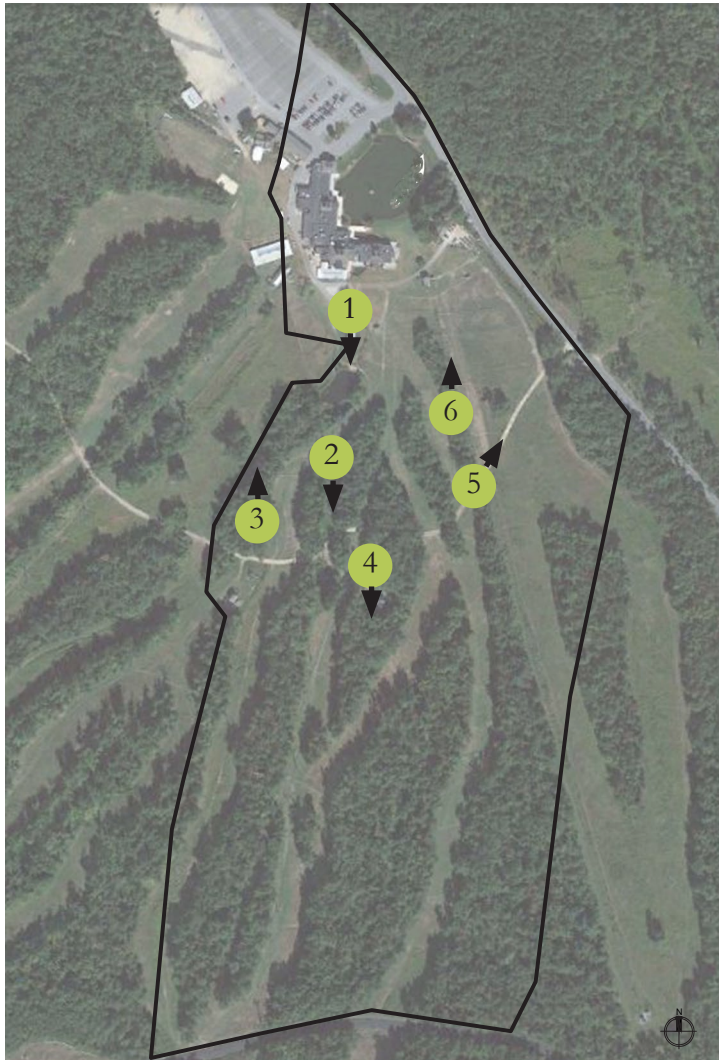


View up the trails taken from where the animal barn will be located.



Extensive impervious base lodge and mountain parking lot.





Stone stream bed and gully running down the mountainside.



Intermittent stream bed running parallel to the ski trails.





Ski trails that will be the site of the Crop West community.



Unpaved road bisecting the site and leading to Bullock Lodge.



Bullock Lodge, which will become a new farm to table restaurant.



View to the west looking down on Community East.



## Concept and Design

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The main concept for this design is Shelter Scape<sup>7</sup>: Capture Resources, Collect Community, Cultivate Food Security and Contribute Sustainable Habitat. It is a regenerative landscape community with earth sheltered houses designed to shelter people, but also to shelter the earth. This concept not only is designed for now and this generation, but also for seven generations in the future.

### Shelter Scape<sup>7</sup>



Capture resources



Collect community



Cultivate food security



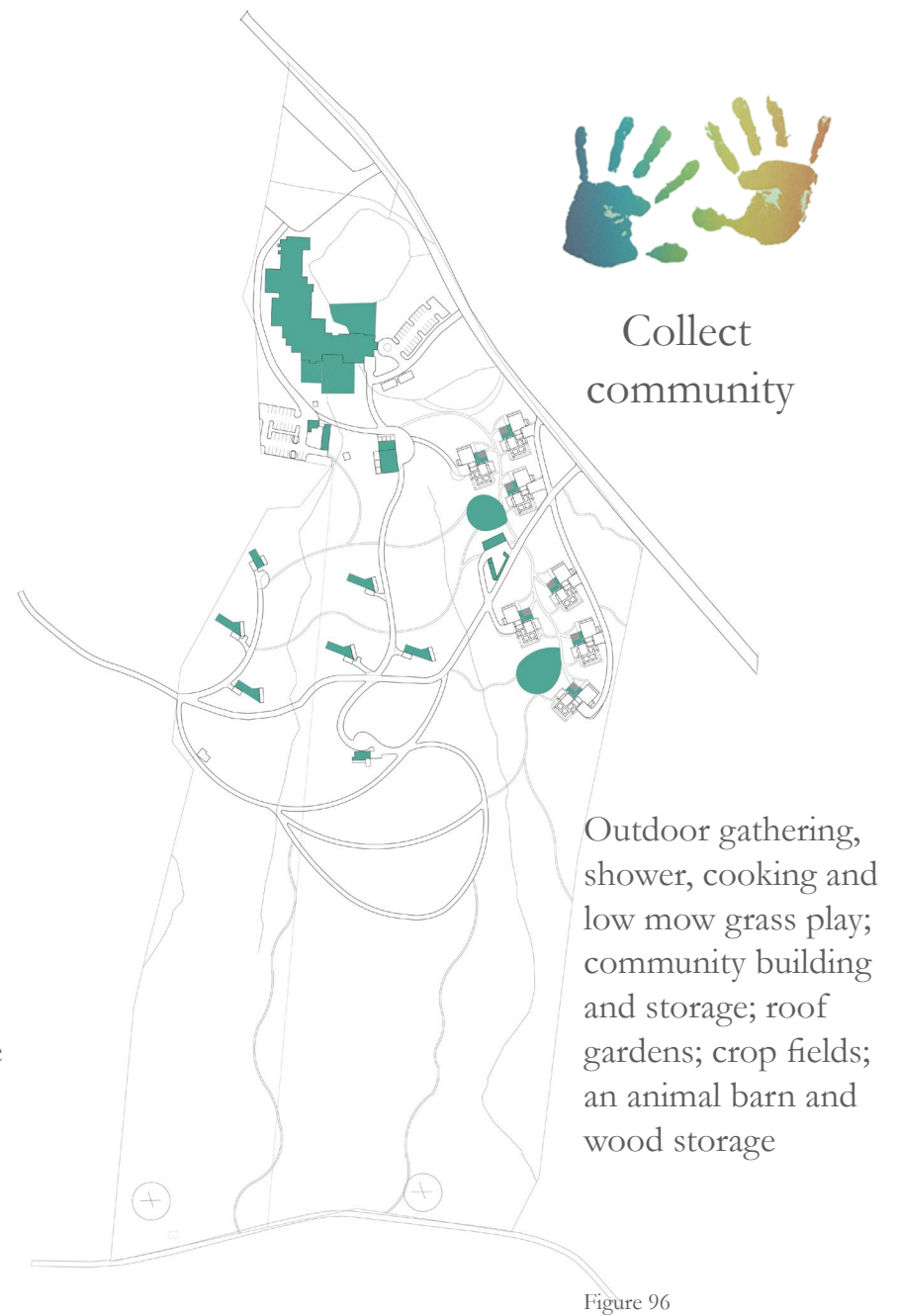
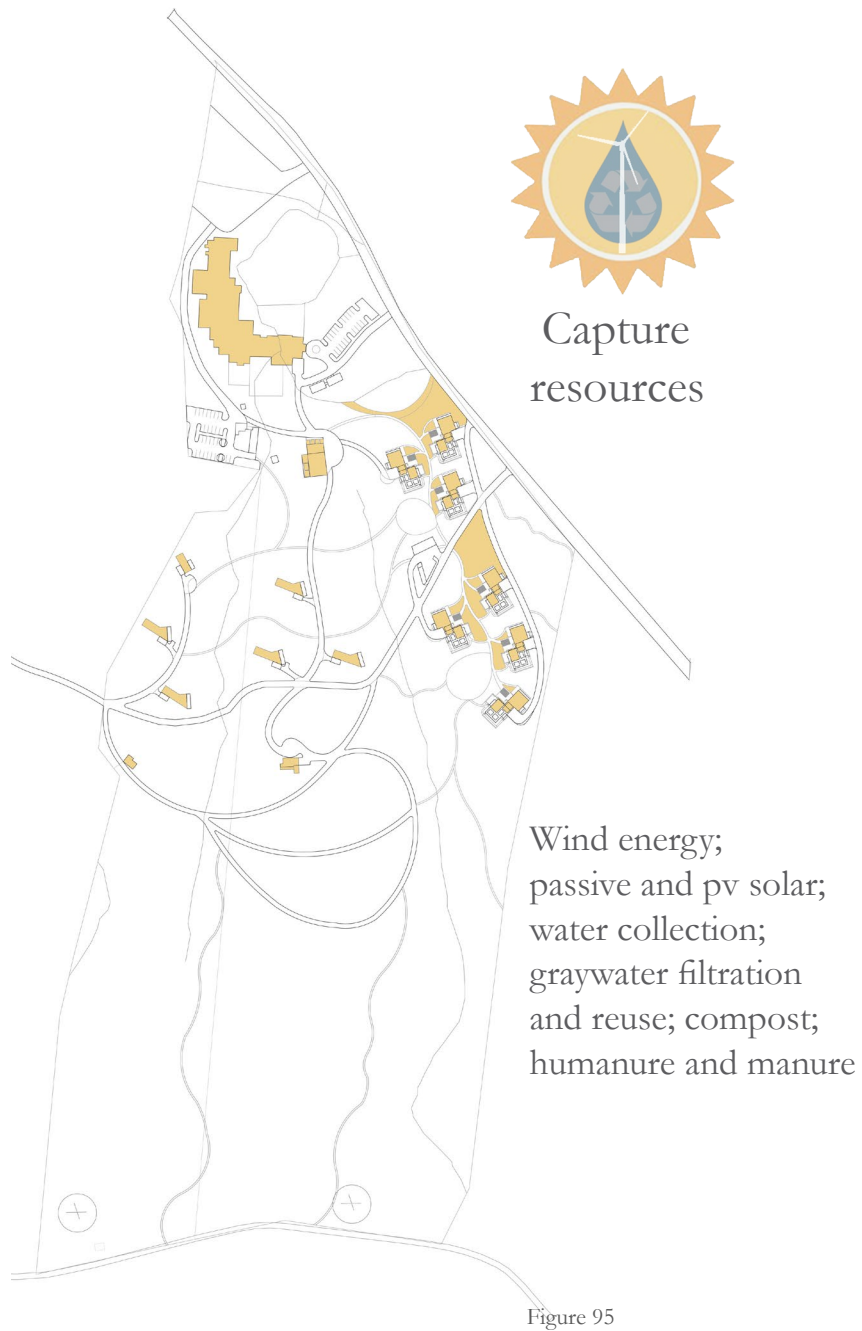
Contribute sustainable habitat

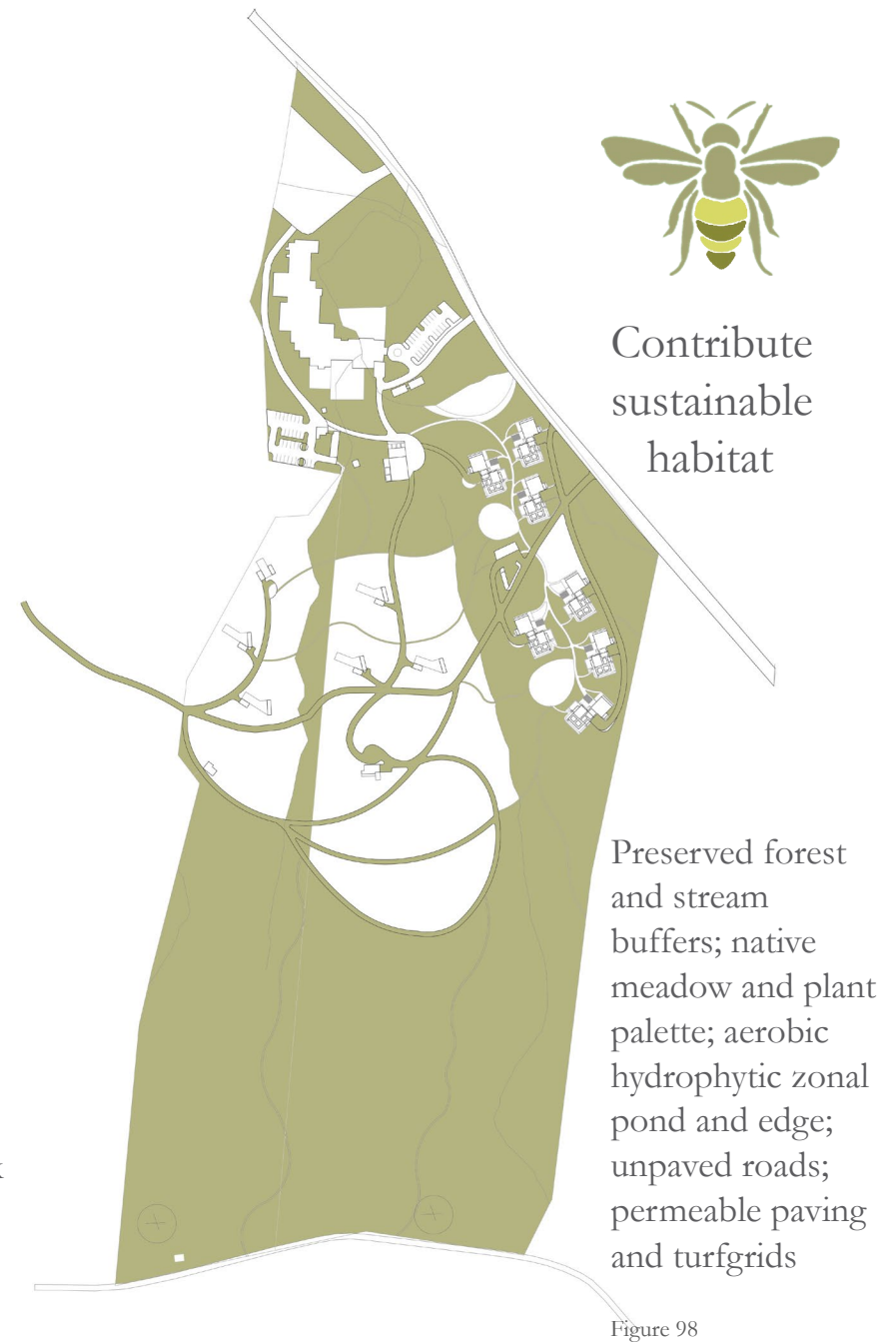
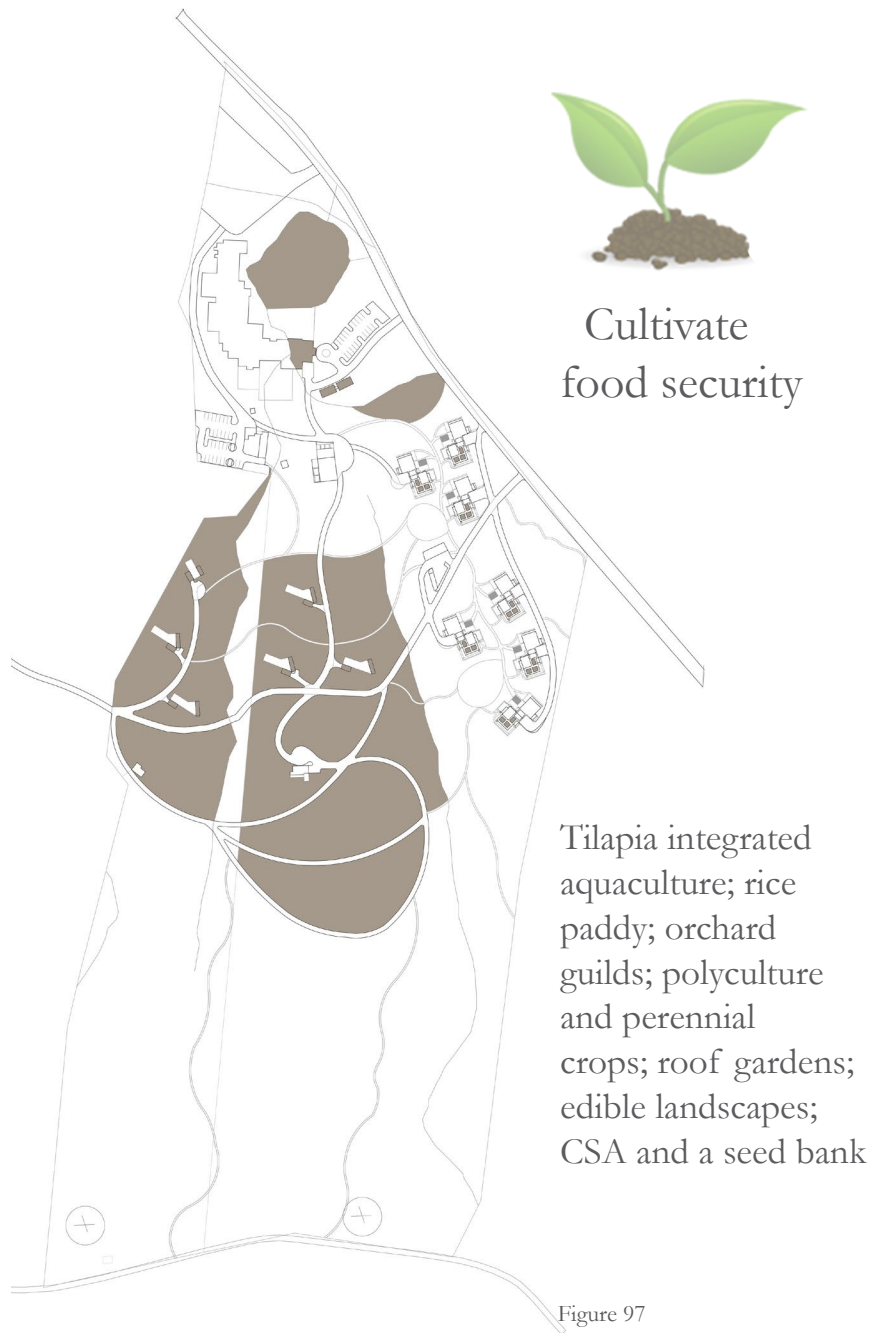
Reading this master's project may bring about questions of the need for so much detailing of architecture. In order, however, to achieve a regenerative landscape architecture is necessary. Landscape should no longer be an after thought or the 'other' when compared with architecture and vice versa. The two disciplines need to be holistically integrated from the beginnings of the design phase, which is why the following houses have been designed to fit the site and have been given as much attention as the landscape features.

Shown on the following pages are: diagrammatical analysis explaining concept features (Figures 95-100); a master plan, detailed plan and landscape integrated floor plan (Fig. 101-103); architectural elevations and an interior floor plan that show community housing and southern landscape integration (Fig. 104-106); rendered sections showing integration of the continuous eastern elevation (Fig. 107, p. 123-24) and the continuous western elevation (Fig. 108, p. 125-27); construction documents (Fig. 109-114) and sketches of crop west (Fig. 115-116).











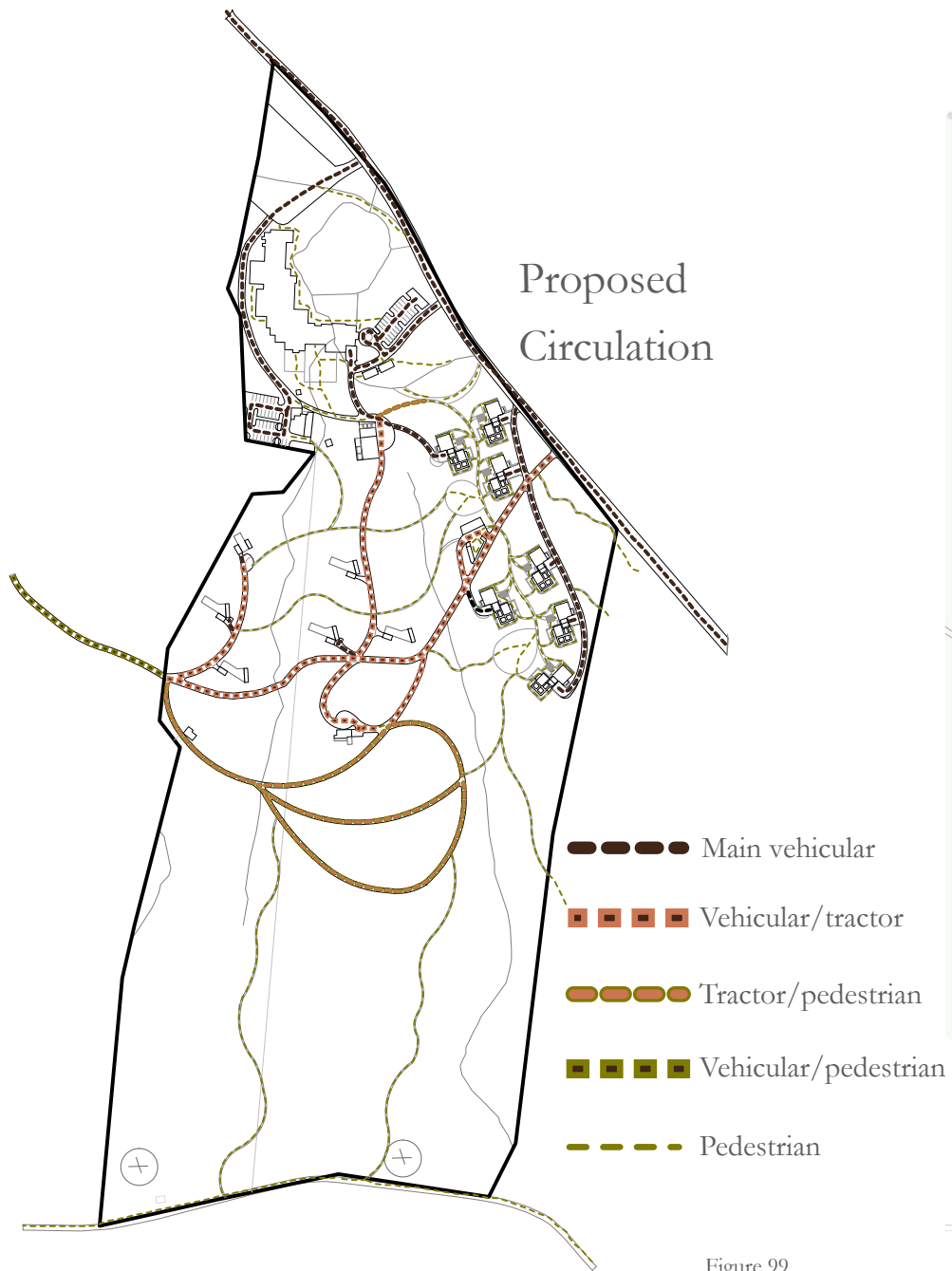


Figure 99

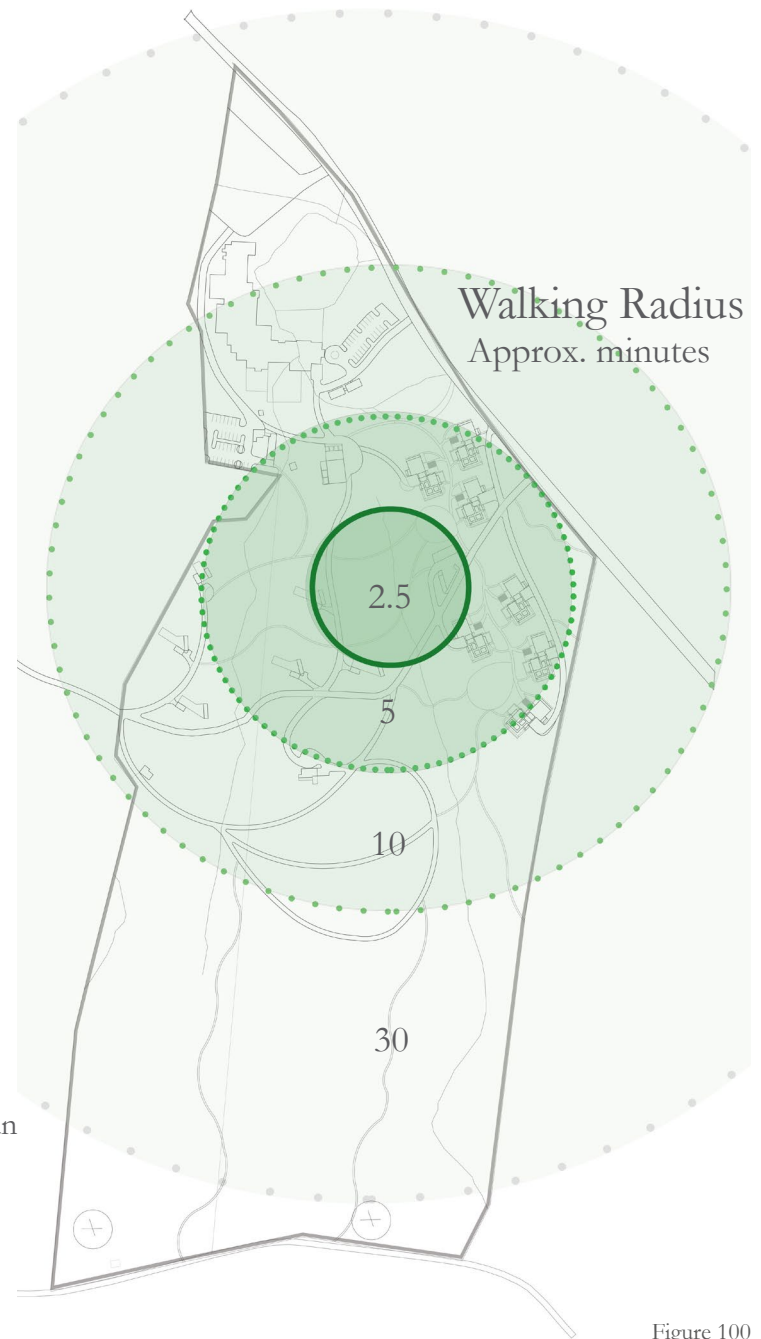


Figure 100



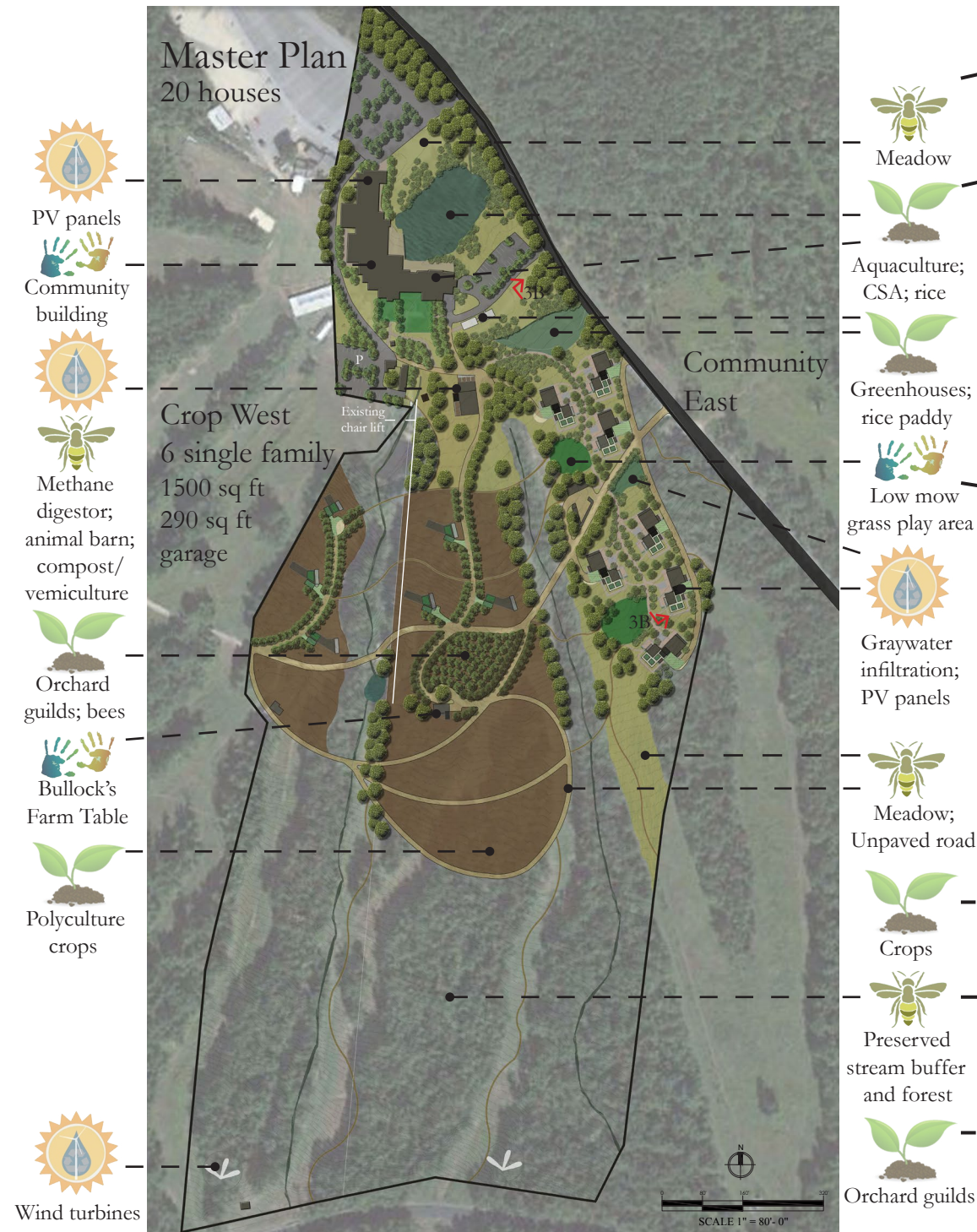


Figure 101

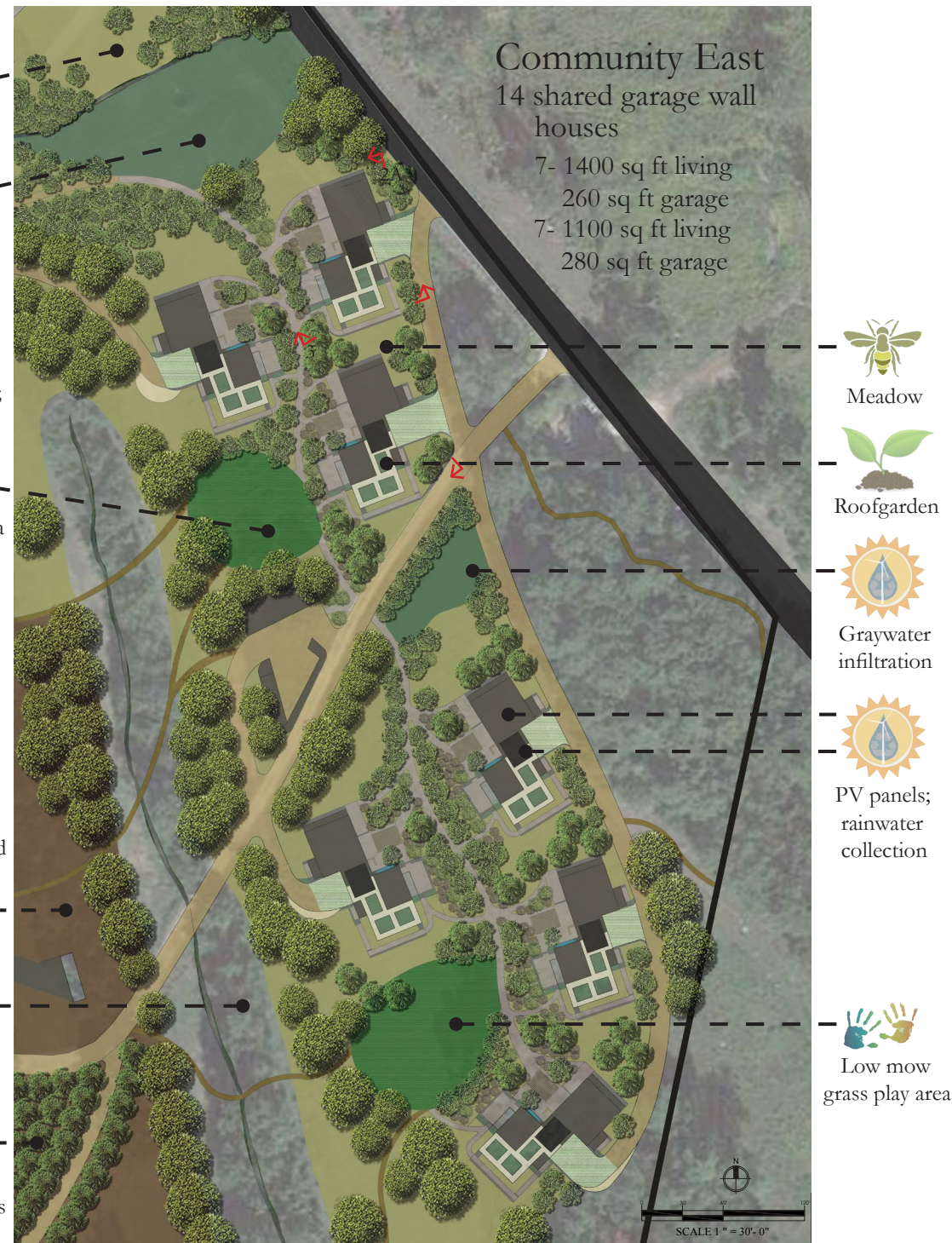


Figure 102



Figure 103



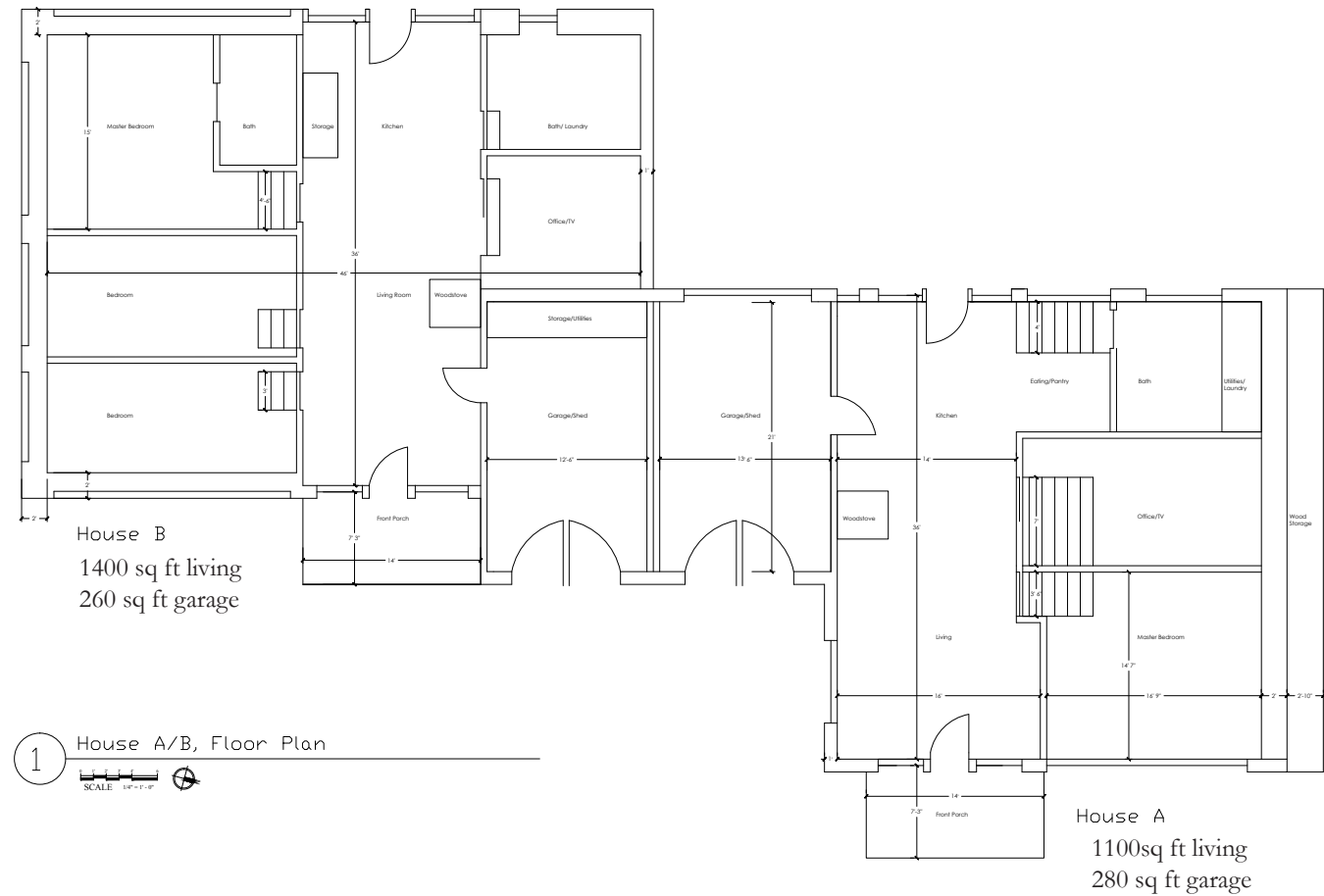


Figure 104

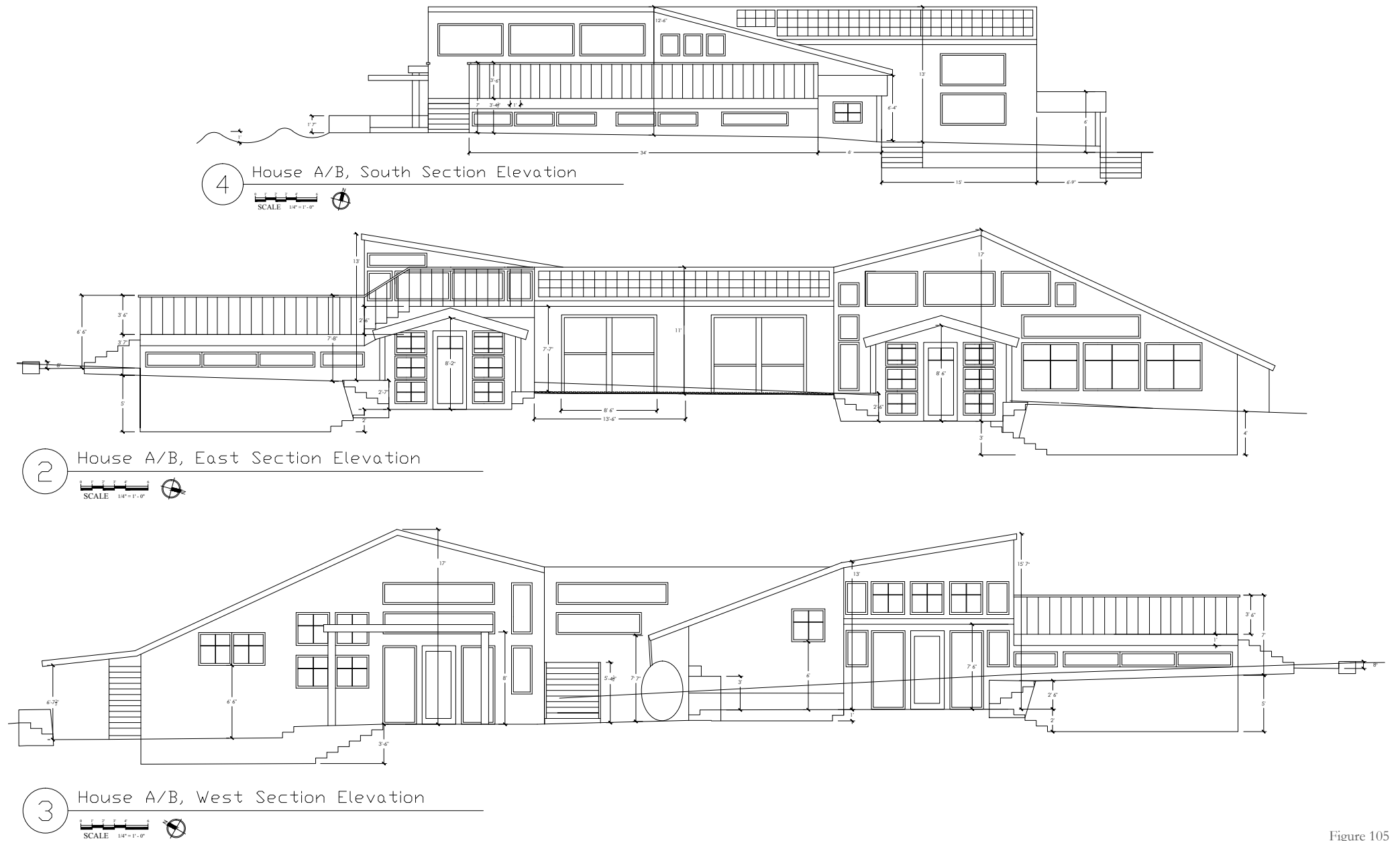
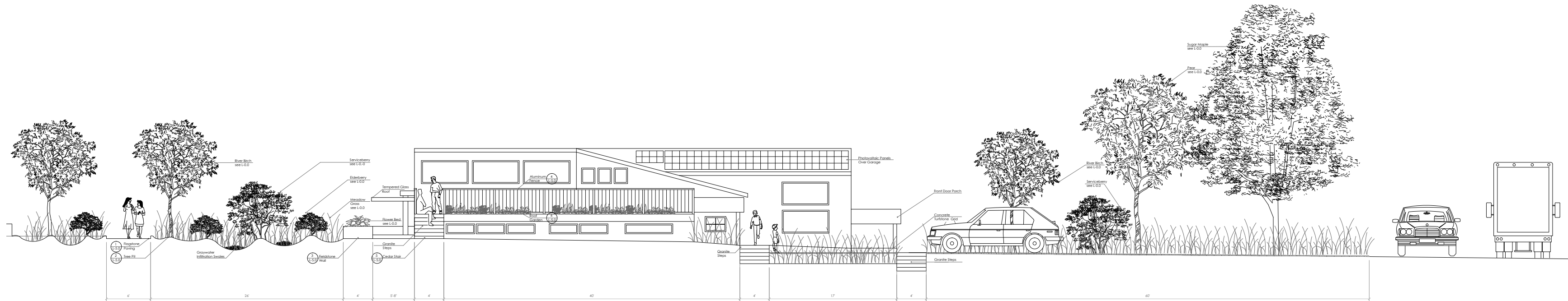


Figure 105



3 House A/B, South Stairs and Driveway Section Elevation

SCALE 1/4" = 1'-0"

Figure 106



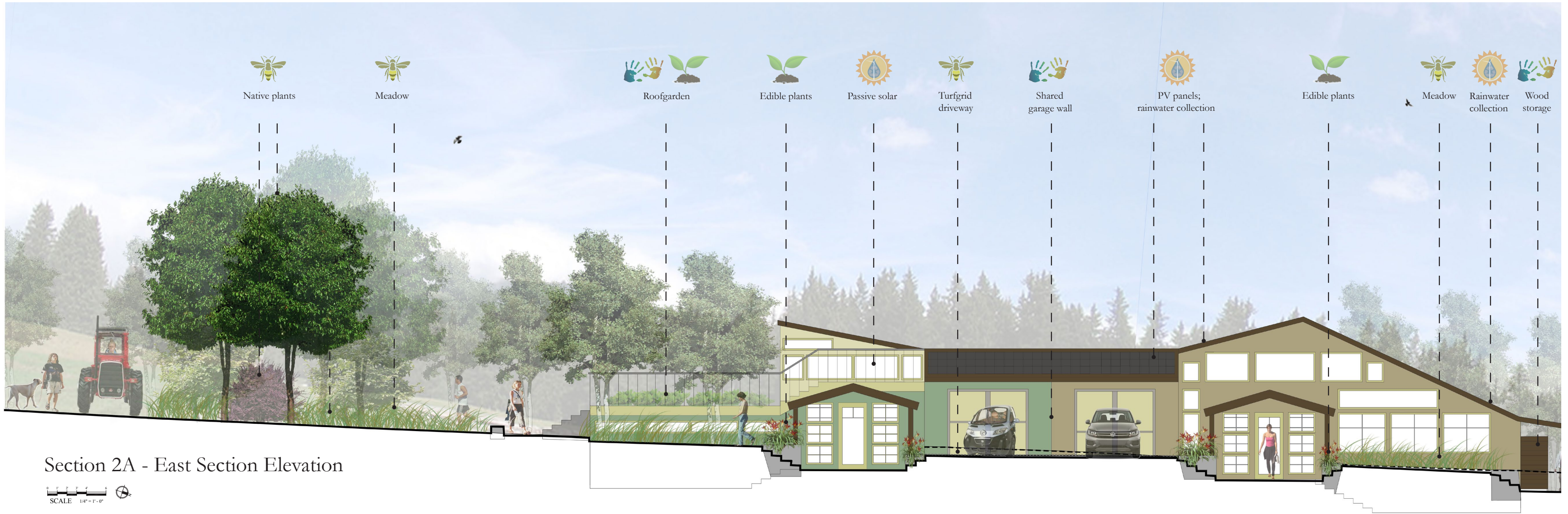






Figure 107



Section 3B - West Section Elevation

SCALE 1/8" = 1'-0"



Open lawn  
gathering space



Meadow;  
native plants



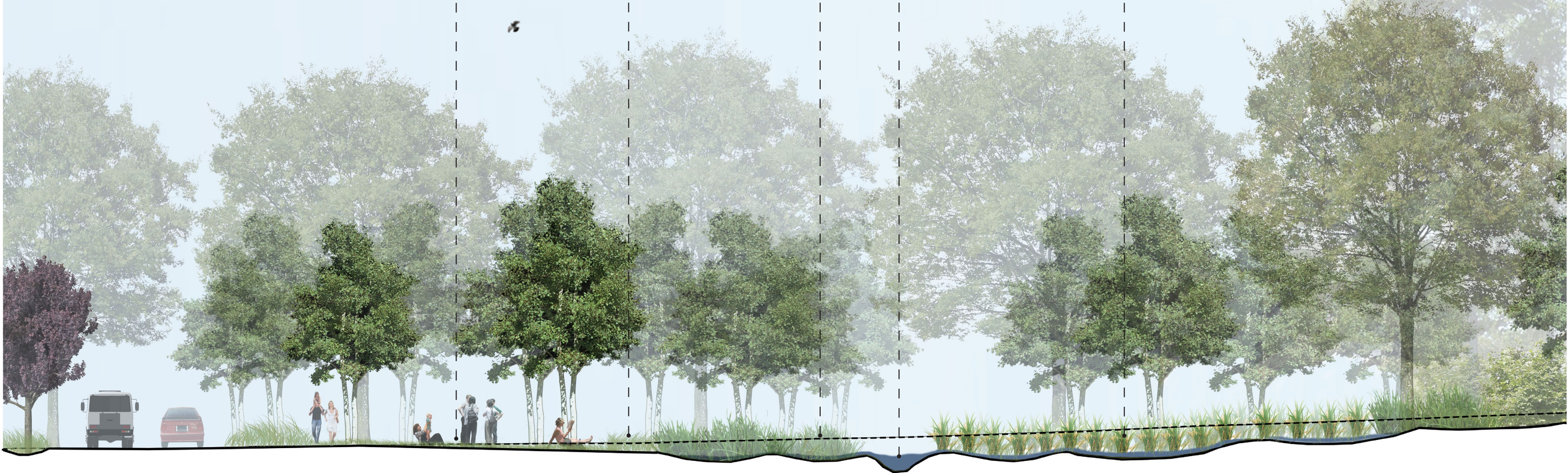
Hydrophytic zone  
native plant edge



Daylighted  
stream



Rice paddy



| 8' | 18' | 91' | 40' | 92' | 39' |



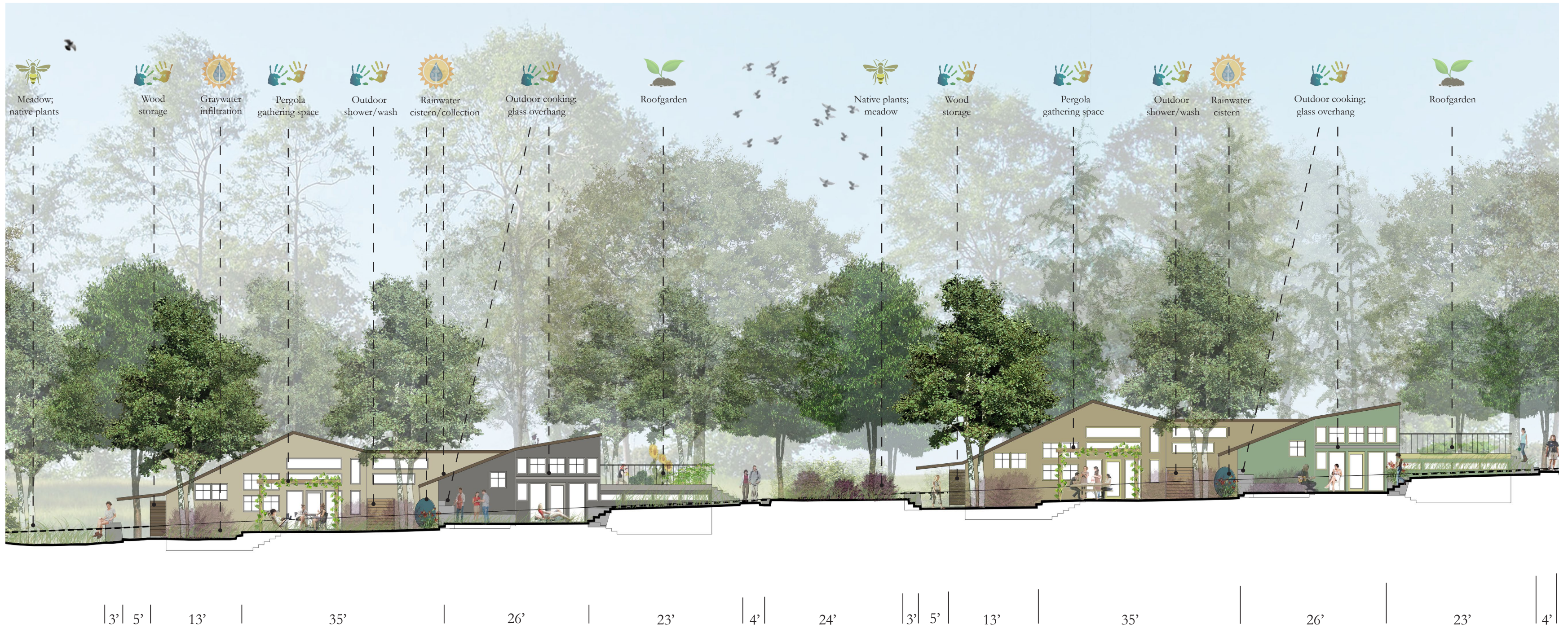






Figure 108



The Shelter Scape<sup>7</sup> master plan encompassing 60 acres of Wachusett Ski Mountain depicts a regenerative community with twenty houses. While other builders might have possibly looked at this site and thought it feasible to build more homes, potentially upwards of at least forty, to fulfill the goal of a regenerative community, building any more than twenty houses seems contradictory. The design therefore balances preserved land, agricultural space, and varying built constructions while offering a largely pedestrian friendly circulation and also a closed site access for tractors and service vehicles (Figure 99). The community shares many features and is clustered together so that from the top houses it would only take ten minutes to walk down to the community building or across to the opposite housing camp. On average, daily walking times to community equipment storage and service areas including mailboxes and recycling, trash and compost drop offs would be five minutes (Figure 100); carts would be provided for ease of transport as well.

Throughout the design process many details and layouts have changed. Because of previously mentioned site limitations, including the north eastern aspect, and the slopes of the developable land being primarily of only 8-15% grades, the design of the houses has been altered and had to be adjusted to fit these natural site conditions. The resulting community houses became a hybrid between earth sheltered and above ground regenerative typologies and are a range of styles designed to appeal to wider audiences and residents of differing life stages and familial needs. These differences are seen on the following pages between the architectural drawings and rendered sections of Community East (Figures 104-108) and the design sketches of Crop West (Figures 115-116).

Community East is the primary clustered housing camp, and it has fourteen shared garage wall houses (Figure 102). Seven houses offer 1400 sq ft living quarters with a 260 sq ft garage or storage space, and seven others offer 1100 sq ft living with 280 sq ft garage or storage space. Circulation in this camp is a pedestrian inner and a main vehicular and tractor outer path (Figure 99, 102). Houses in this camp have the baths, kitchens, and outdoor showers on the same wall to allow pipe sharing and effective graywater infiltration; bedrooms on either the south/east, or the south/west; are largely open concept interior plans with each having a central wood stove with wood storage on the north outside wall; and each has porches and outdoor gathering spaces on the east and west (Figure 103-105). On the south side they are six feet above grade to



both benefit from earth sheltered insulating capabilities and to allow strongest natural light penetration in the interior, and to also be close enough to grade to provide a comfortable stepped access to the roof gardens (Figure 105-106). The houses are similar to a double unit duplex as each double unit shares amenities, but too, each offers both private and community space. The design of the unit is repeated up the mountain and even though the houses are clustered, their often low profile and integration with landscape potentially makes them seem less obtrusive (Figure 107-108).

The construction documents show landscape materials, planting, grading, and construction details for some designed elements located in Community East (Figures 109-114).

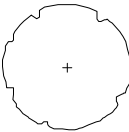
Crop West offers five slightly bigger single family homes each at 1500 sq ft living space and a 290 sq ft garage or storage space (Figure 101). One house in Crop West offers 1000 sq ft of living space, and it is located on the slightest slopes, nearest the community building. The circulation here is more traditional with individual house driveway access, but pedestrian only trails connect the different clusters and Community East (Figure 99, 101). Houses in this camp are completely earth sheltered on the southern side to meet grade, offer an underground connected garage, and easy access to the roof garden (Figure 115). Their orientation is more north eastern as they follow the natural topography and contours, but a glass covered porch and outbuild on the east and clerestory windows facing south offer good light penetration (Figure 116).

Construction Documents List

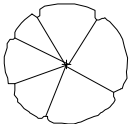
- L- 0.0 Landscape Notes and Legends
- L- 1.0 Layout and Materials Plan Overview
- L- 1.1 Layout and Materials Plan
- L- 2.0 Grading Plan
- L- 3.0 Planting Plan
- L- 4.0 Landscape Sections/ Elevations
- L- 5.0 Landscape Details

Notes
<p><b>Plants:</b></p> <p>All plants are to be disease and pest free upon close inspection. Roots in container plants are not to be wrapped around soil mass or visible from the outside of the container.</p> <p>All trees and plants in each selection are to match grouped appearance, and overall size.</p> <p>Trees are to have a strong central leader(s), straight trunk, and full rounded crown. Single stem trees are to have a minimum 4' trunk height. They are to be marked with the northern orientation when picked from nursery and planted with some orientation on site.</p> <p>Species and variety substitutions are to be approved by Landscape Architect.</p> <p><b>Root balls:</b></p> <p>Are to be of a vase like shape, with a sturdy not lumpy base, rounded top burlap edges, and a wire basket with twine wrapped enclosure. Trees in the root ball are to be tight, straight and the top root flare should be visible at the top of the ball. Balls with excessive moss, vegetative growth, or excessively deteriorating burlap are to be avoided.</p> <p><b>Planting:</b></p> <p>All containers, burlap, twine, and wire are to be removed prior to planting. Wire baskets, twine, and burlap are to be cut and disposed of after root ball is in hole. Staples are to be collected and disposed of properly. Foam trunk protectors are to be removed after plant is planted.</p> <p>All plants will be planted as outlined by American Standards for Nursery Stock (ANSI) guidelines. Planting is suggested as applying Bone Meal root fertilizer to the bottom of hole before backfilling with common borrow. Manures and compost can be mixed if site soil is poor. A thorough watering is to be done with half of hole backfilled, and then again when hole is filled to dissipate air pockets.</p> <p>3' of natural non dyed mulch is to be spread on top of each hole in appropriate optimum growth drip line radius when hole is filled.</p> <p>Trees are not to be staked unless exceptionally windy site situations persist as to be approved by Landscape Architect.</p> <p><b>Terraced Rice Paddy:</b></p> <p>General- Provide water retentive soil, clay to loam not sand or gravel. Install drains if necessary according to engineer specifications or add gravel swales. Provide access to irrigation source, or running stream.</p> <p>Preparation- Till beds removing all weeds. Grade 2-4" tall berms to keep water contained and line with plastic sheeting. Work in organic matter (loam mixed compost, or composted mixed manure.</p> <p>Seed- Soak seed for 12-24 hours before planting.</p> <p>Planting- Sow seed at 1 oz per 100 sq ft., gently tamp and cover with 3" mulch. Water frequently.</p> <p>Maintenance- Thin to 3- 4" apart in rows 9-12" apart when seedlings 5-7" tall. Flood with 1-8" of water when seedlings are 15' tall. Drain each night and flood in morning to deter mosquitos and encourage aerobic conditions. Weed regularly to limit plant competition.</p> <p><b>Grading:</b></p> <p>Cut top soil and earth shall be stockpiled on site to be used for backfill and fill procedures. Surplus materials shall not be removed from site unless approval by Landscape Architect.</p> <p>Pitch evenly between spot grades.</p> <p>All paved areas must pitch to drain at a minimum of 1% or 1/8" per foot or as specified.</p> <p>Where new paving meets existing paving meet line and grade of existing paving.</p> <p>Grades within handicap parking spaces and maneuvering shall not exceed 1.5% in any direction unless otherwise noted.</p> <p>Cross slopes of pedestrian walks shall not exceed 1.5%.</p> <p>Slopes of pedestrian walks shall not exceed 4.75% unless otherwise noted.</p> <p>At limits of grading the general contractor shall blend new grading smoothly into existing grading.</p> <p>The contractor shall verify existing grades in the field and report discrepancies immediately to the architect or appropriate project manager prior to starting work.</p> <p>Any areas outside limit of work that are disturbed shall be restored to conditions prior to start of site work.</p> <p>The contractor shall comply with Massachusetts General Laws Chapter 82 Section 40, as amended, that states proper work conditions, hours, noise limits and contractor responsibility.</p> <p><b>Standing Seam Metal Roof:</b></p> <p>To be installed by licensed contractor as to manufacture specifications. Contractor should be local such as Everlast Roofing. Roof style is to be standing seam, with charcoal or bronze color finish as specified by Synergy Color Systems. Roofing company will also install gutters around and draining into collection cisterns.</p> <p><b>Photovoltaic Solar Panels:</b></p> <p>To be installed by licensed contractor as to manufacture specifications. Contractor should be local such as Full Sun Solar. Licensed electrician will set up battery and outlet hookups.</p> <p><b>Turfstone Concrete Reinforced Paving Grid:</b></p> <p>To be installed by licensed contractor as to manufacture specifications. Dimensions measure 23 5/8" x 15 3/4" x 3 1/8" thick. Product is to be cut to size when applicable. Spaces are to be filled with groundcover plugs or seed as specified in above plant list and referenced in L- 3.0.</p> <p><b>Outdoor Cooking Area:</b></p> <p>To be installed by mason as to cook top and preparation area guidelines. Cook top or charcoal basin to be specified by contractor or interior designer specialist. Electrical outlets are to be installed by licensed electrician.</p> <p><b>Cistern:</b></p> <p>See above under Standing Seam Metal Roof, and to be specified by irrigation specialist and stormwater engineer.</p> <p><b>Outdoor Shower and Wash area:</b></p> <p>To be installed by plumber and licensed contractor. Landscape Architect/ Designer will specify floor tiles and wood shelving areas. Plumber/ contractor will specify shower head and knobs. Drains should flow into swales and gray water infiltration beds. Electrician will install outdoor outlet nearby.</p> <p><b>Other Questions:</b></p> <p>Should be directed to appropriate project manager related to questioned material. Landscape Architect is not responsible for incorrect information not related to field scope.</p>

Plant List						
SYM.	QTY.	Botanical Name	Common Name	Size	Variety Notes	Notes
Trees						
SM	10	Acer saccharum	Sugar Maple	4-5' Caliper, B&B	ALB non host- new strain	Tight ball, Specimen
P	6	Pyrus communis 'Warren'	European Pear	#3-4 CG or 3" Caliper B&B	or comparable	Specimen
RB	47	Betula nigra	River Birch	4-5' Caliper, B&B, Clump	Available borer resistant	Tight ball, no noticeable defects
Shrubs						
S	13	Amelanchier canadensis 'Thiessen'	Serviceberry	#3-4 CG or 10' B&B, Clump	or 'Paleface', or comparable	10' OC
E	56	Sambucus canadensis 'York'	Black or Common Elderberry	#3-4 CG or 10' B&B, Clump	Pull about half of each	5' OC
		Sambucus nigra 'Black Lace'	European Elderberry			
Groundcover						
GC		Ajuga reptans	Bugleweed	Plugs, or seed, 3,000 sq ft.	Best availability	Separate plugs at roots
		Trifolium repens	White Clover	Seed	Best availability	Clover seed at 2 oz per sq ft
Perennials						
RI	1025 lbs	Oryza sativa	Paddy or Deep Water Rice	Seed, 16,400 sq ft.	Paddy or Deep Water Rice	1 oz per 100 sq ft. Direct sow
OB	17	Leave open for homeowner approval		Varies	Suggest shallow roofing	To fill with flowers or vegetables
M		Native Existing Meadow				Let grow, mow or burn 3x/year



EX  
Existing Trees



SM  
Acer saccharum



P  
Pyrus communis



RB  
Betula nigra



S  
Amelanchier canadensis



E  
Sambucus



RI  
Oryza sativa



M  
Meadow



GC  
Groundcover



OB  
Open Bed



Standing Seam Metal Roof



Photovoltaic Panels



Green Roof Garden



Concrete Building Roof



Tempered Glass Porch Panel



Existing Asphalt Main Road



Unpaved Road



Turfstone Concrete Paving Grid



Flagstone Pavers



1" Crushed Stone



Granite Block Steps



Dry Laid Fieldstone Wall



Cedar Board



Low Mow Turf Grass

TOS Top of Stairs

BOS Bottom of Stairs

TOW Top of Wall

BOW Bottom of Wall

FFE Finished Floor Elevation

CL Swale Centerline



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Shelter Scape 7

A Regenerative Landscape with  
Earth Sheltered Housing

Wachusett Ski Mountain  
Princeton,MA

Contributing Parties

Owner-- Massachusetts Department of Conservation
Architect-- ad terram Canary Web; NewTerra
Landscape Architect-- ad terram Canary Web
Structural Engineer--Michael Davidsohn LLC
Lighting Consultant-- A. Arsenault and Sons Lighting
Sustainability Consultant-- NewTerra-Clouse & DiPasquale

Landscape  
Notes & Legends

Project Number: 9

Drawn: LK

Checked: JpG

Approved: MD; FS

Date: 4/5/15

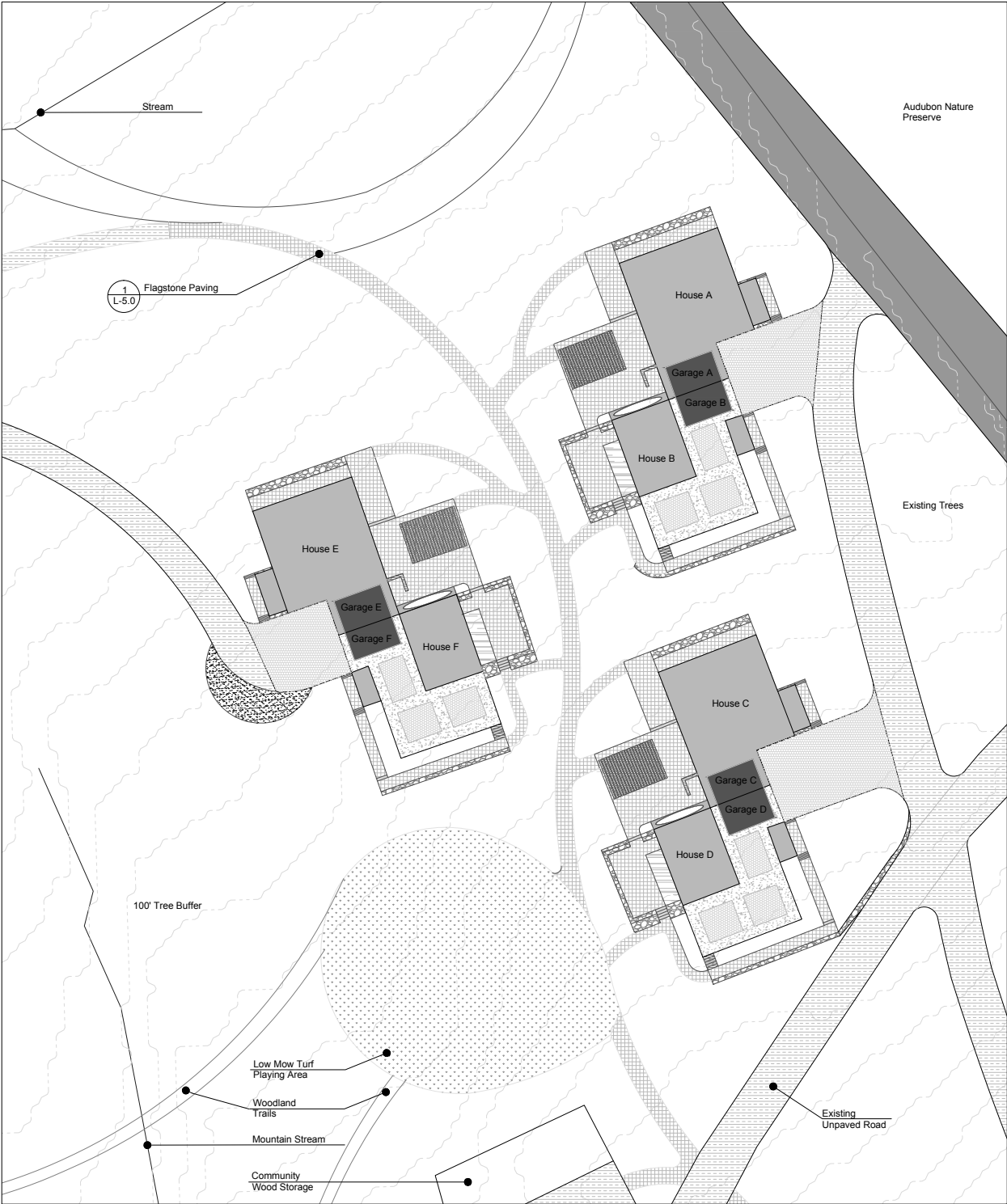
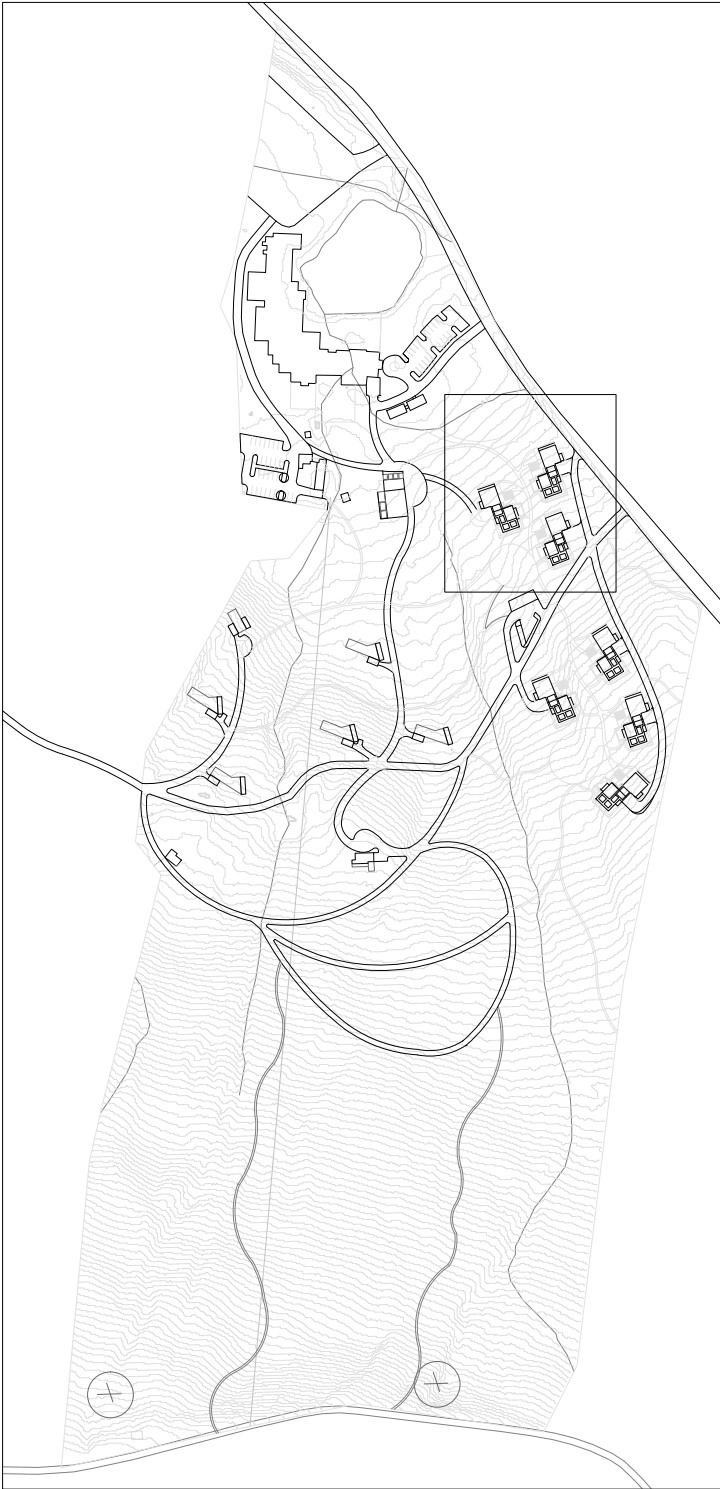
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Rev 2: 3/29/15	Rev 8: 4/21/15
Rev 3: 4/3/15	Rev 9: ---
Rev 4: 4/4/15	Rev 10: ---
Rev 5: 4/5/15	Rev 11: ---
Rev 6: 4/10/15	Rev 12: ---

L- 0.0

Figure 109





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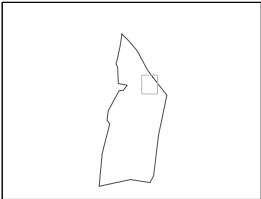
## Shelter Scape 7

A Regenerative Landscape with Earth Sheltered Housing

Wachusett Ski Mountain  
Princeton, MA

### Contributing Parties

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Lighting Consultant--	A. Arsenault and Sons Lighting
Sustainability Consultant--	NewTerra-Clouse & DiPasquale



## Layout & Materials Plan Overview

Project Number: 9

Drawn: LK

Checked: JpG

Approved: MD; FS

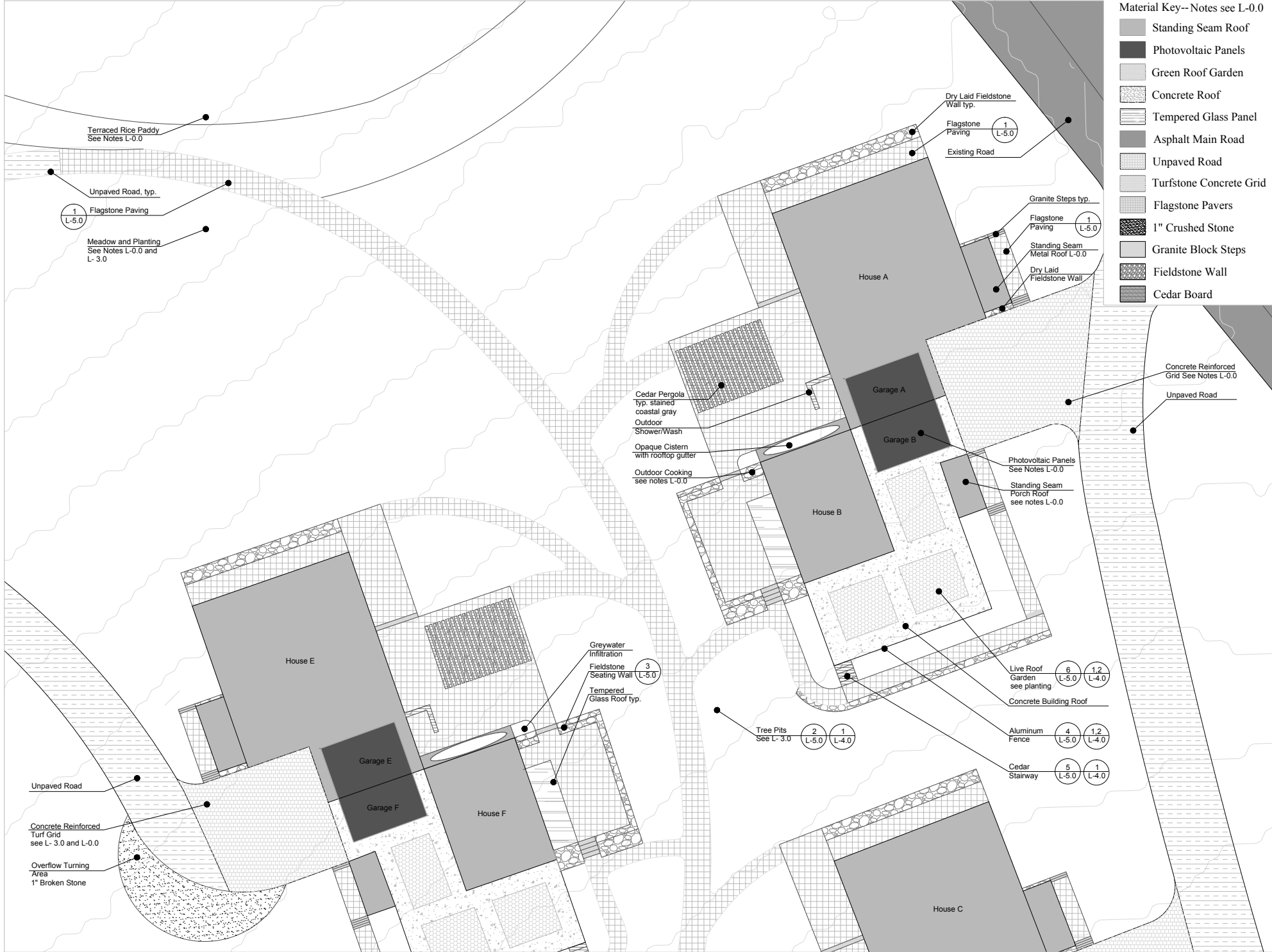
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Rev 4:	4/4/15	Rev 10:	---
Rev 5:	4/5/15	Rev 11:	---
Rev 6:	4/10/15	Rev 12:	---

L- 1.0

Figure 110



- Material Key-- Notes see L-0.0
- Standing Seam Roof
  - Photovoltaic Panels
  - Green Roof Garden
  - Concrete Roof
  - Tempered Glass Panel
  - Asphalt Main Road
  - Unpaved Road
  - Turfstone Concrete Grid
  - Flagstone Pavers
  - 1" Crushed Stone
  - Granite Block Steps
  - Fieldstone Wall
  - Cedar Board



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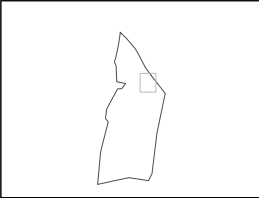
## Shelter Scape 7

A Regenerative Landscape with Earth Sheltered Housing

Wachusett Ski Mountain  
Princeton, MA

### Contributing Parties

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Landscape Architect-- ad terram Canary Web
Structural Engineer--Michael Davidsohn LLC
Lighting Consultant-- A. Arsenault and Sons Lighting
Sustainability Consultant-- NewTerra-Clouse & DiPasquale



## Layout & Materials Plan

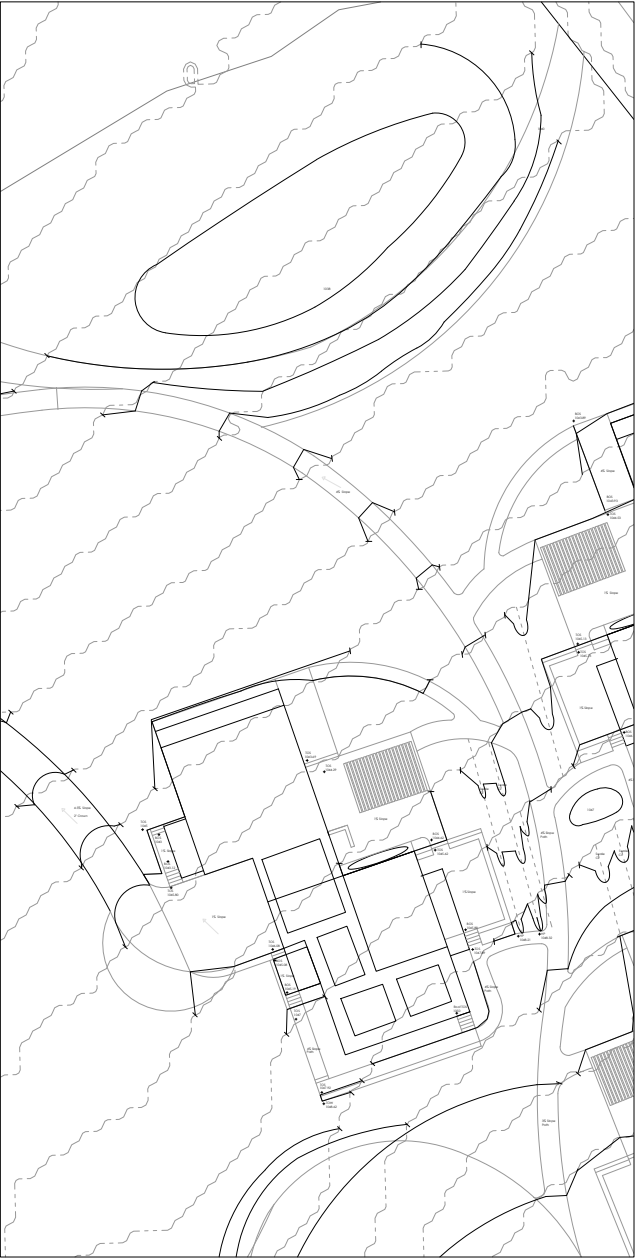
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Rev 4:	4/4/15	Rev 10:	---
Rev 5:	4/5/15	Rev 11:	---
Rev 6:	4/10/15	Rev 12:	---

## L- 1.1

Figure 111





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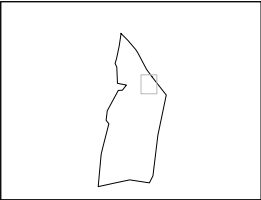
## Shelter Scape 7

A Regenerative Landscape with  
Earth Sheltered Housing

Wachusett Ski Mountain  
Princeton, MA

### Contributing Parties

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Structural Engineer-- Michael Davidson LLC
Lighting Consultant-- A. Arsenault and Sons Lighting
Sustainability Consultant-- NewTerra-Clouse & DiPasquale



## Grading Plan

Project Number: 9

Drawn: LK

Checked: JpG

Approved: MD; FS

Date: 4/5/15

Scale: 1" = 20'- 0"

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Rev 2: 3/29/15	Rev 8: ---
Rev 3: 4/3/15	Rev 9: ---
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Rev 5: 4/5/15	Rev 11: ---
Rev 6: 4/12/15	Rev 12: ---

L- 2.0

Figure 112



Plant Key-- Notes see L-0.0

- EX- Existing Trees
- SM- Sugar Maple
- P- Pear
- RB- River Birch
- S- Serviceberry
- E- Elderberry
- RI- Rice
- M- Meadow
- GC- Groundcover
- OB- Open Bed



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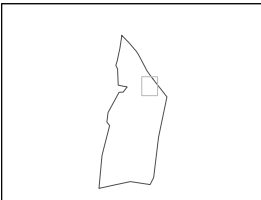
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A Regenerative Landscape with  
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Structural Engineer--Michael Davidson LLC  
Lighting Consultant-- A. Arsenault and Sons Lighting  
Sustainability Consultant-- NewTerra-Clouse & DiPasquale



## Planting Plan

Project Number: 9

Drawn: LK

Checked: JpG

Approved: MD; FS

Date: 4/5/15

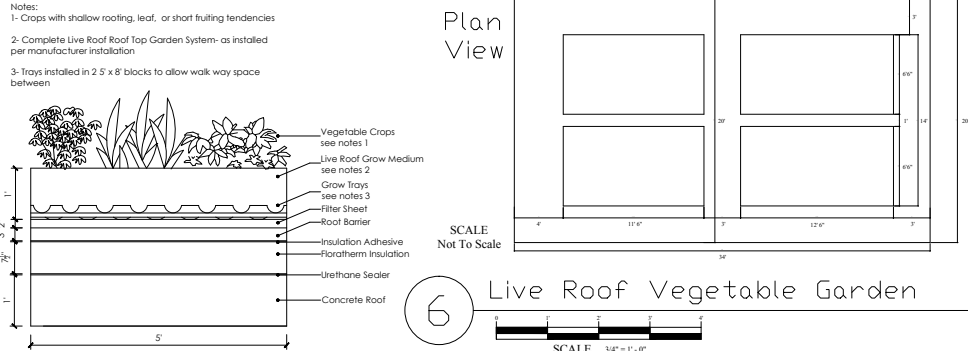
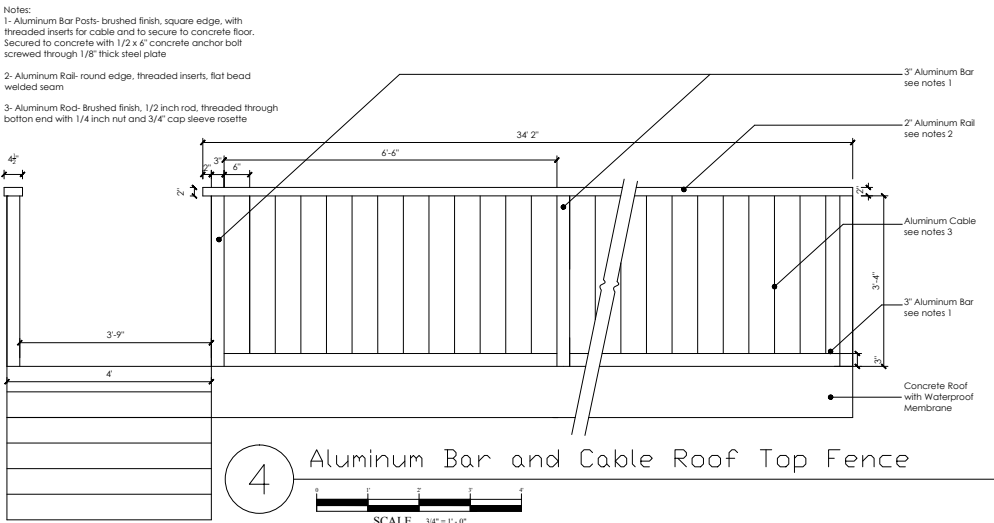
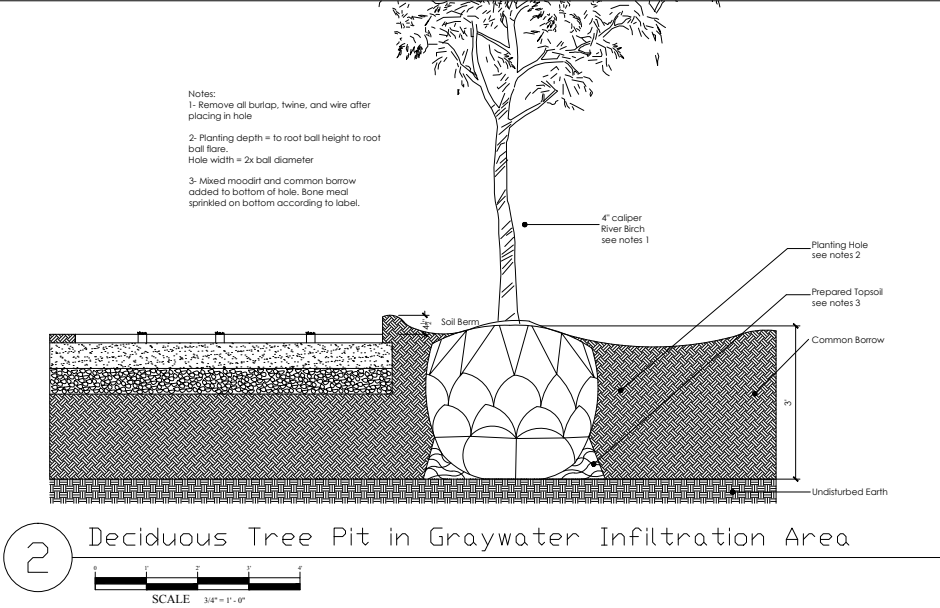
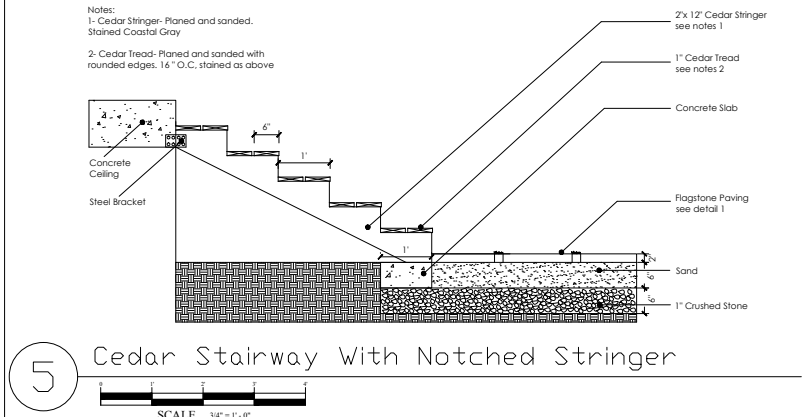
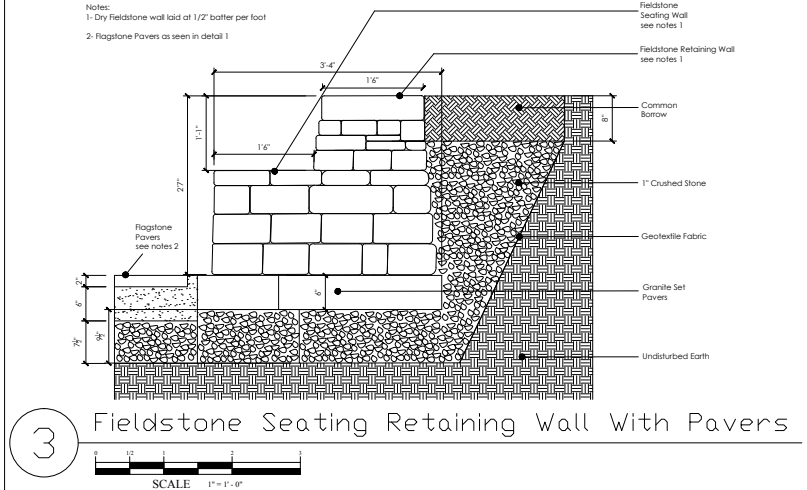
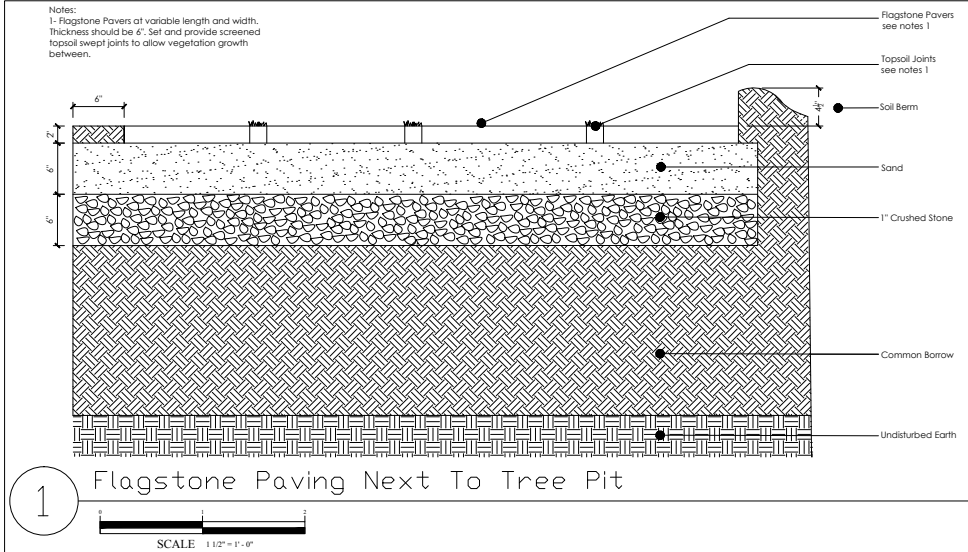
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Rev 4:	4/4/15	Rev 10:	---
Rev 5:	4/5/15	Rev 11:	---
Rev 6:	4/20/15	Rev 12:	---

L- 3.0

Figure 113





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Seal

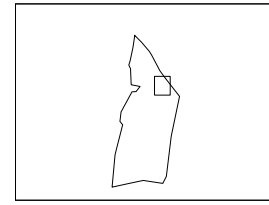
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## Shelter Scape 7

A Regenerative Landscape with Earth Sheltered Housing

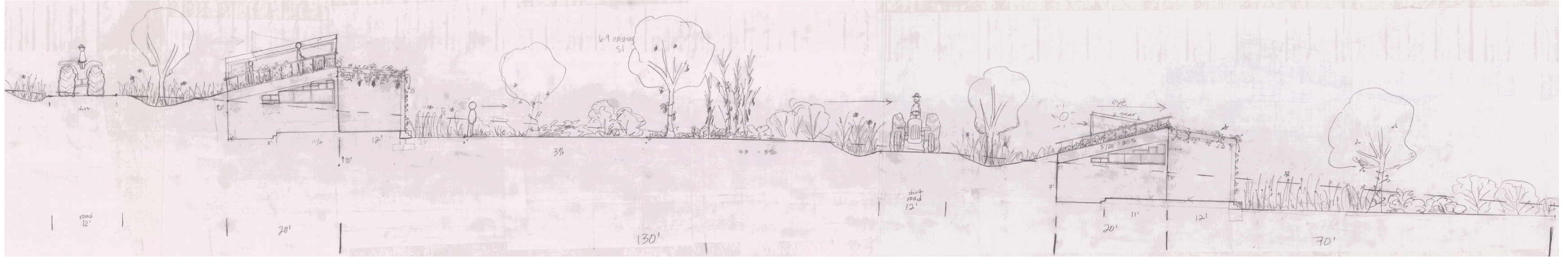
Wachusett Ski Mountain  
Princeton, MA

Contributing Parties	
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## Landscape Details

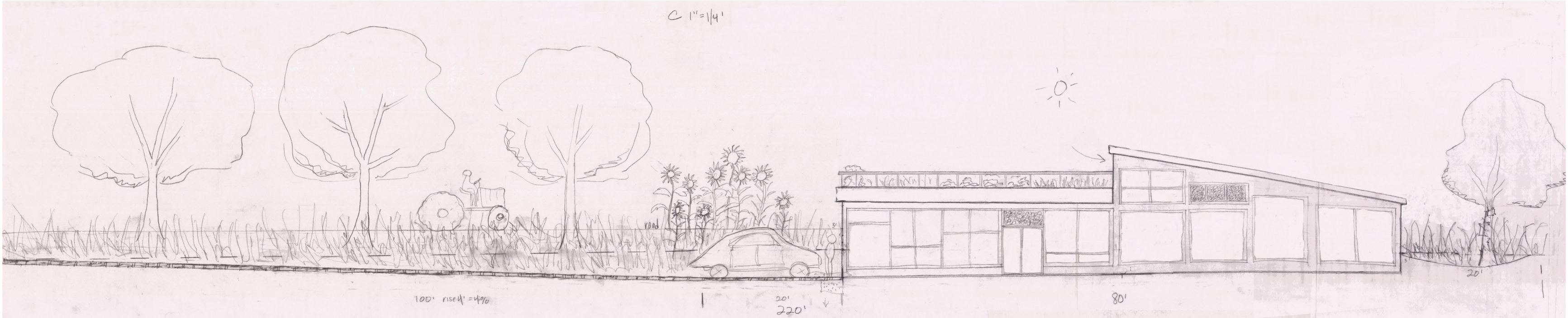
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Rev 5:	4/5/15
Rev 6:	4/18/15
Rev 7:	4/19/15
Rev 8:	4/20/15
Rev 9:	---
Rev 10:	---
Rev 11:	---
Rev 12:	---



Crop West Landscape Elevation

Figure 115





Crop West Housing Sketch

Figure 116

Other elements included in the concept and master plan of this design are as follows: the existing ski lodge is a very large building that would be repurposed as the community center with a wellness area and yoga and dance studio; small art studios with wood, fiber, clay, glass etc. shops, and viewer galleries; commercial kitchen and cooking space; demonstration and meeting space; aquaculture lab; seed bank; market and community store to supply goods and products needed on site and to offer retail sales of goods produced on site to the general public; and a CSA cafe, small brewery, and a butcher to also provide outside revenue. The existing small hotel lodge will remain to provide a “resident experience” to paying non residents or free to those interested in the farmhand work study program. Functions not programmed or thought of here will absolutely be included, and as needs of the community will change over time, interior programs of the space will change and be amended as well (Figure 101).

Bullock lodge, as seen in pictures in the Design Site Photo Tour (p. 114) was built in 1930's as the former mountain lodge. It was closed for years after the main lodge was constructed, and in 2009 it again reopened to provide snacks, homemade doughnuts, and refreshments to the winter guests (Wachusett 2015). This proposal has designed a 500 sq ft addition to the historic 1000 sq ft building to serve as a space for the new on site generated farm to table restaurant. This restaurant will also be a noted destination, as while the existing unpaved road leading up to it will provide handicap, elderly, and service needs, the main way of guest transport up to the restaurant will be via the new, amended gondola style chair lift on the western side of the site. The added parking lot will provide ample space for patron vehicles (Figure 101).

Additional added structures in this plan include two 780 sq ft greenhouses located near the community building and CSA, a 2600 sq ft animal barn, and a connected 1000 sq ft equipment storage building (Figure 101).





<http://ethandthornphotos.files.wordpress.com>

## CHAPTER 6: CONCLUSION

### Summary

---

Many important and lengthy topics went into this master's project. Regeneration is the holistic integration of humans and their behavior, ecological processes, and technology. Human behavior and our daily practices affect our world the greatest. We are what we eat, we are what we do, and we are what we build. Earth sheltered strategies represent a good ecological partnership with the landscape. No other modern housing style can beat its environmentally friendly credibility. Earth sheltered communities offer the housing style and human behavior changes that are necessary for worldwide population increases and climate change effects. Clustering of homes, resources, and amenities seems to make the most logical sense. Based on historical precedent and the trial and error involved with how historical and ancient populations lived, we can learn what styles and practices worked best and which were necessary for a flourishing population. There is no need to reinvent something that has already been done or has been proven lasting and effective. Like many have said before, we just need to get back to our roots. Elements discussed in this paper are relevant to this new perception change. This change can happen anywhere and to anyone. Sites that need remediation for economic, ecological, or community needs perhaps should be altered first as they will be the spoke that gets the wheel moving. Regenerative Earth Sheltered Communities represent the best effort of sustainability we have achieved, and they solidify the notion that we humans will finally take responsibility for our behavior.



As mentioned earlier, for true regeneration to be achieved architecture must be integrated with landscape from the early design phases. In this coming age we can no longer have one without the other, or think of one as being separate from the other. Landscape and architecture are the forces that shape our world and which allow our existence upon it. True regeneration, again though is not thinking of our buildings and design features *upon the land* but being *in partnership with*. We must change our views and perceptions to survive. We can build a better relationship with our world, we just have to try.

Shelter Scape7: A Regenerative Landscape Community helps make that change. It captures resources, collects the community, cultivates food security, and contributes sustainable habitat for all species. It can be part of the spark that ignites the fire, for us and the future.

## Lessons Learned

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Communities like this can exist anywhere, but they are a design challenge. As this design did, others may have to adapt to site features and constraints of hydrology, slopes, aspect and topography, local codes and regional aesthetics. Due to their custom nature, they may require higher building costs, slower turn around, and less immediate demand and profit. But that does not mean they should not be designed.

This community changed throughout the assessment and design phase. Originally it was conceptualized to be scattered homes set through the mountain with no driveway access or garage. I thought either by 2060 residents would not have traditional cars, or that if they did, residents would be okay with parking them at the base of the mountain and taking the gondola chair lifts up to their homes. This was perhaps strict and unrealistic, and based on a critique and a request from a resident at Pioneer Valley Co-housing, the houses got garages.

Another change discussed previously was the site area itself. Developing in the NHESP sedge habitat was never intended, but this design provides an ecological management practice for that species, as un mowed succession would wipe out the grass land species in totality.

The overall intent of the master plan changed as well. It was first thought that this plan could be a phased plan, offering rental ski condominiums working in conjunction with ski mountain operations, and then a conversion of those rentals to permanent housing units and the regenerative landscape after ski operations ceased. Because the current leasee uses every inch of the property for ski trails and visitor space and Wachusett Ski Mountain is tiny in comparison to other ski mountains, the available and accessible housing space is extremely limited. Balance Rock Road, the unpaved access road bisecting the mountain, could provide access, but during ski season it is covered by four feet of snow and utilized as part of the ski trails. A potential area does exist on the east side of the site directly parallel to Mountain Road, and an early plan depicted that arrangement. But again based on the fact that this area would only support four condos and they would have to be ten feet off of this road and arranged in a linear group, the phased plan became unworkable. This final plan depicts a master plan intended to be implemented after ski operations cease instead, which could be of economic benefit to Princeton and the Massachusetts DCR.

The last change and the most major one was the hybridization and required design of the houses. Before thorough site analysis, I never intended to design the houses, and thought that common earth sheltered typologies or kit designs utilizing passive solar techniques would work. But because of the site's northeastern aspect and not the ideal south, 8-15% slopes in the main camp of Community East, need for garages, and all previously mentioned limitations, these houses had to be designed as hybrids between earth sheltered and traditional typologies. Perhaps one could say though, in the end it worked out, and that overall, when taken as a whole community including Crop West, the hybridization provides a better range of houses which could appeal to a broader audience.

All factors considered, this project brought about questions of human responsibility and relationships with the landscape. Perceptions must adapt to fit our changing climate, both in our personal lives and also our professional. We all must seek a more collaborative partnership with our landscape; architects, landscape architects and designers need to work more collaboratively to develop this holistic change. Let's instead now partner with the earth and integrate regenerative and ecological communities for human habitation.

Truly, it is uncertain what the future will bring. One thing we do know for sure is...



“It is not the strongest animal that survives,  
nor the fastest,  
but the one most adaptable  
to change”

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- Leon C. Megginson,  
paraphrasing Charles Darwin  
(Falk 1, 2013).



<http://www.gardenofwales.org.uk>



## Annotated Bibliography

Afristar Foundation. "What We Do" 2013. Accessed March 3 2015. <http://afristarfoundation.org/>.

Web page explaining the foundation's work and allowing the download of educational materials.

Alvarez, Lizette. "Long Secret Fallout Shelter Was a Cold War Camelot" *The New York Times*, October 1, 2011. Accessed March 2, 2015. [http://www.nytimes.com/2011/10/02/us/for-kennedy-a-secret-shelter-was-a-cold-war-camelot.html?\\_r=0](http://www.nytimes.com/2011/10/02/us/for-kennedy-a-secret-shelter-was-a-cold-war-camelot.html?_r=0).

Online version of newspaper article describing Kennedy's fallout shelters.

California State Polytechnic University, Pomona. "The John T. Lyle Center for Regenerative Studies" February 17, 2015.

Accessed March 2, 2015. <https://www.cpp.edu/~crs/>

Website of the Lyle Center- detailing history, site information, regenerative practices and current educational events.

Chiras, Dan, 2003. "Earth Sheltered Homes: Comfortable, Affordable and Energy Efficient". *Mother Earth News*, February/March 2003.

Accessed April 27, 2014. <http://www.motherearthnews.com/green-homes/earth-sheltered-homes>

Dan Chiras' article discusses the advantages of earth sheltered homes, includes information on earth sheltered homes that are comfortable, affordable and energy efficient.

Daifuku, Hiroshi. "The Pit House in the Old World and in Native North America". *American Antiquity*, vol.18, no.1.

Society for American Archaeology, (July, 1952): 1-7. <http://www.jstor.org/stable/276236>. Accessed March 19, 2015.

Well known and respected journal article on Pit House history and construction.

Earthship Biotecture. "Construction Materials". Accessed February 28, 2015. <http://earthship.com/construction-materials>

Main website for earthship founder Michael Reynolds. It details construction specifics and has kit designs.

Falk, Ben. *The Resilient Farm and Homestead: An Innovative Permaculture and Whole Systems Design Approach*. White River Junction, VT: Chelsea Green Publishing, 2013.

How to manual of regenerative and resilient landscape techniques based on authors' own experience on his farm and homestead.

Harkness, Rachel. "Earthships: The Homes That Trash Built". *Anthropology Now*, vol.3, no.1. (April 2011): 54-65.

<http://www.jstor.org/stable/10.5816/anthropologynow.3.1.0054>.

Journal article discussing earthship culture.

Holmgren, David, Bill Mollison. *Permaculture One: A Perennial Agriculture for Human Settlements*. Tyalgum, Australia: Tagari Publications, 1990.

Fundamental Permaculture book as outlined by the originators.

Jenkins, Joseph. *The Humanure Handbook: A Guide to Composting Human Manure*. Grove City, PA: Joseph Jenkins Inc, 2005.

The author published influential and best known book on the subject of humanure composting.

Ludwig, Art. *Create an Oasis with Greywater: Choosing, Building and Using Greywater Systems*. Santa Barbara, CA: Oasis Design, 2014.

Well known, complete revised and expanded book on greywater methods, techniques and design and construction applications.

Lyle, John Tillman. *Design for Human Ecosystems*. Washington, D.C: Island Press, 1999.

Book discussing effective designs that encompasses all species while harmonizing with the earth.



Lyle, John Tillman. *Regenerative Design for Sustainable Development*. New York, NY: John Wiley and Sons, 1994.

Lyle's book discussing case studies, his Lyle Center and outlining the methodologies of regenerative design.

Meijenfeldt, Ernst von and Maritgeluk et al. *Below Ground Level: Creating Spaces for Contemporary Architecture*. Basel, Switzerland: Birkhauser, 2003. Book detailing case studies and presenting the case for underground building.

Mollison, Bill, Reny Mia Slay. *Introduction to Permaculture*. Tyalgum, Australia: Tagari Publications. 1991.

Introductory book outlining and discussing the main principles and techniques of permaculture.

National Museum of Iceland. Historic Buildings Collection "Hofskirkja Church in Örafi" Historic Buildings Collection, Iceland. Accessed March 3, 2015. <http://www.thjodminjasafn.is/english/for-visitors/historic-buildings-collection/nr/3430>. Website with information and pictures about the historic church.

National Park Service. U.S. Department of the Interior. 2015. "History and Culture, People and Places" Walnut Canyon National Monument, Arizona, February 27. Accessed March 2, 2015. <http://www.nps.gov/waca/learn/historyculture/index.htm> Website about history, culture, location and offering site photos of Walnut Canyon National Park.

Nelson, Mark. *The Wastewater Gardener: Preserving the Planet One Flush at a Time*. Santa Fe, NM: Synergetic Press, 2014. Essential book on a brief history of composting toilets and application and case studies on their efficacy.

Northern Lights Iceland. 2015. "Icelandic Turf Houses". Accessed March 1, 2015. <http://www.northernlightsiceland.com/the-icelandic-turf-houses/>.

Nationally funded web page describing historical landmarks in Iceland.

Princeton Master Plan Steering Committee. “Master Landuse Plan” September 19, 2007. Accessed May 1, 2015.

<http://www.town.princeton.ma.us/openspace.pd>

Princeton master landscape plan which through 2012 ammendments has not changed regarding noted zoning recommendations.

Quinn-Szcesuil, Julia. “Life in a berm.” *Worcester Living*, Fall 2014, 41-46.

Newspaper and magazine article, with pictures, about the Southborough home and the residents.

Renski, Henry, Lindsay Koshgarian, and Susan Strate. “Longterm Population Projections for Massachusetts Regions and Municipalities”.

Umass Donahue Institute, 2013. [http://pep.donahueinstitute.org/UMDI\\_LongTermPopulationProjectionsReport\\_2013.11.pdf](http://pep.donahueinstitute.org/UMDI_LongTermPopulationProjectionsReport_2013.11.pdf).

Report discussing projected population changes to year 2030.

Rose, Kenneth D. *One Nation Underground: The Fallout Shelter in American Culture*. New York and London: New York University Press, 2001.

Interesting book about the chain of events leading to the fallout shelter craze of the 1960’s.

Short, William R. and Hurstwic, 2015. “Turf Houses in the Viking Age”. March 18, 2015. Accessed March 19, 2015.

[http://www.hurstwic.org/history/articles/daily\\_living/text/turf\\_houses.htm](http://www.hurstwic.org/history/articles/daily_living/text/turf_houses.htm)

Website about the historical construction techniques of Viking turf houses.

Solacity Incorporated 2006. “The Truth about Small Wind Turbines” 2015. Accessed February 24, 2015.

<http://www.solacity.com/smallwindtruth.htm>

Website giving information about wind turbines, their requirements, and the differences between solar panels.



Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y.Xia, V. Bex and P.M. Midgley. “Climate Change 2013: The Physical Science Basis”. Working Group I Contribution to the *Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom and New York, NY, USA : Cambridge University Press, 2013.

Report on scientific analysis and modeling related to climate change. This working group is geared to scientists and policy makers.

Suagee, Dean B. “ Solar Energy: Let’s Get Passive!” *Natural Resources and Environment*, vol.26, no.2. *Oil and Gas: Post Deepwater Horizon*. (Fall 2011): 54-56, accessed 18 March 2015. <http://www.jstor.org/stable/23054881>.

Journal article discussing the lack of, or current ( most is from the 1980’s) information or construction of earth sheltered homes.

Sustainable Sources. “Passive Solar Design” 2015. Accessed March 2, 2015. <http://www.passivesolar.sustainablesources.com/>

Website started in 1994, put out by a collective in Austin Texas that seeks to inform the public about sustainability.

Town of Princeton. “About Princeton” 2015. Accessed April 27, 2014. [http://town.princeton.ma.us/Pages/PrincetonMA\\_Assessors/index](http://town.princeton.ma.us/Pages/PrincetonMA_Assessors/index)  
Princeton town webpage.

United States Census Bureau, American FactFinder; Department of Commerce. “2013 Projections” 2015. Accessed February 24, 2015. <http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

U.S. Government website to find information on census, projection population and demographic data.

United States Department of Energy. “Articles” Efficient Earth Sheltered Homes. June 24 2013. Accessed April 27, 2014. <http://energy.gov/energysaver/articles/efficient-earthsheltered-homes>

Web page describing definitions and benefits of Earth sheltered housing.

Vetsch Architektur. Peter Vetsch. Earth Houses. 2014 Earth House Architecture. Modified 2014. Accessed April 9, 2014.

<http://www.erdhaus.ch/main.php?fla=&lang=en&cont=start>

Design firm website page, link about Earth sheltered housing community in Switzerland.

Virilio, Paul. *Bunker Archeology*. New York, NY: Princeton Architectural Press, 1994.

Book detailing chronological dates, sketches and an overview of the history and archeology of war time bunkers.

Wachusett Mountain. "About the Mountain"; "Bullock Lodge/ Cider House" 2015. Accessed April 14, 2015.

<http://www.wachusett.com/TheMountain/AboutWachusett/FactsHistory/tabid/58/Default.aspx>

<http://www.wachusett.com/TheMountain/ResortServices/BullockLodge/tabid/547/Default.aspx>

Wachusett Ski Mountain informational website.

Wang, Lucy. 2015. "Turenscape's regenerative wetland park cleans up a post-industrial landscape in China," Inhabitat, January 12, 2015, accessed March 4, 2015.

<http://inhabitat.com/turensapes-regenerative-wetland-park-cleans-up-a-post-industrial-landscape-in-china/>.

Wells, Malcolm. *The Earth Sheltered House: An Architect's Sketchbook*. White River Junction, VT: Chelsea Green Publishing Company, 1998.

Sketchbook and design manual for inspirational designs and Wells own built projects across the country.

Wikimedia Foundation Inc. 2014. "Walnut Canyon National Monument" Wikipedia. August 23. Accessed March 2, 2015.

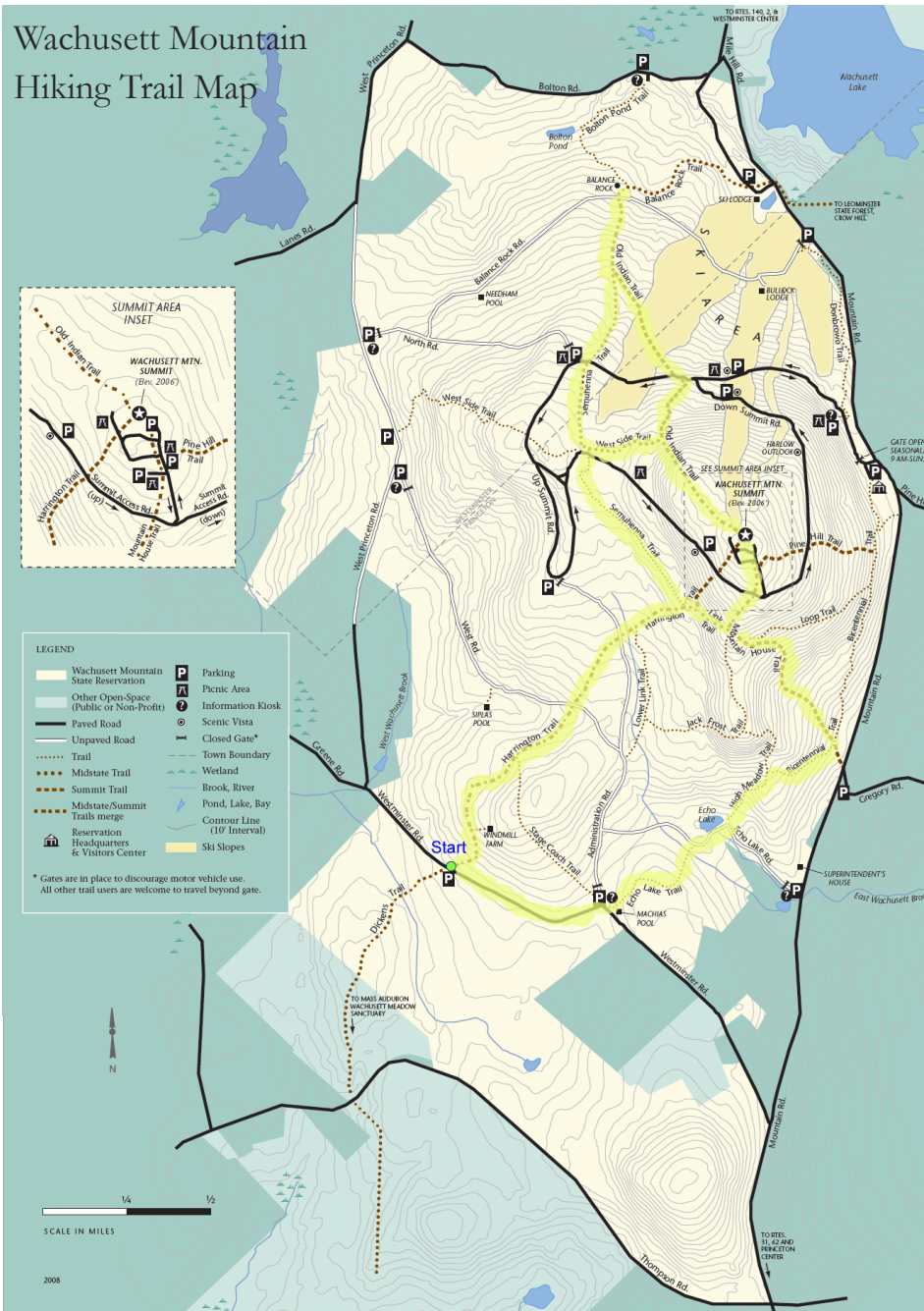
[http://en.wikipedia.org/wiki/Walnut\\_Canyon\\_National\\_Monument](http://en.wikipedia.org/wiki/Walnut_Canyon_National_Monument)

Website giving location to Walnut Canyon National Park.



## Appendix

### Wachusett Mountain Hiking Trail Map



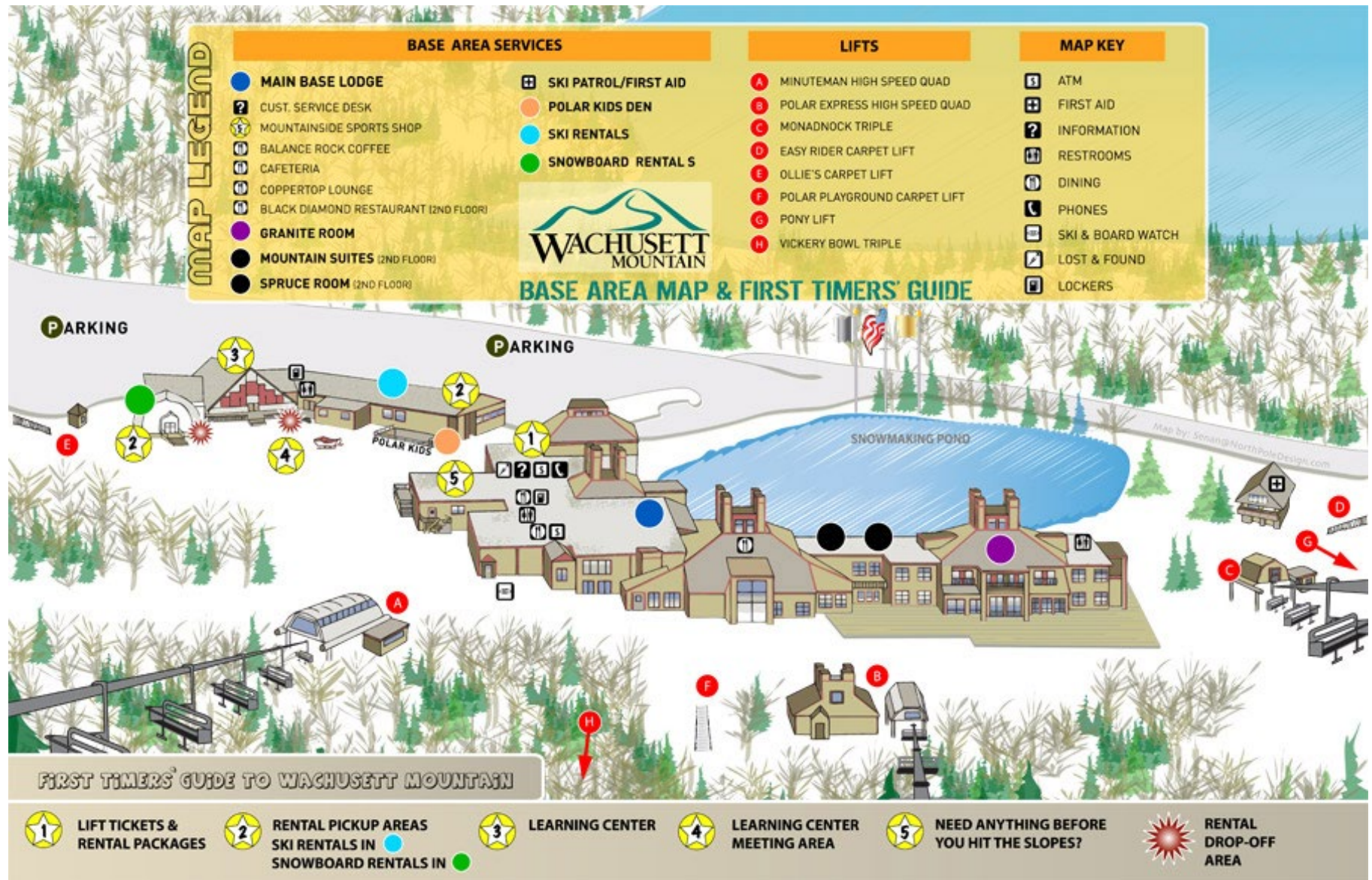
### Wachusett Mountain Ski Trail Map



<http://www.hikenewengland.com>; <http://www.wachusett.com>



## Wachusett Mountain Lodge and Base Area Map



<http://www.wachusett.com>



